THE

POPULAR SCIENCE MONTHLY.

OCTOBER, 1874.

THE FOSSIL MAN OF MENTONE.

By THEODORE GILL, M. D., Ph. D.

THE attention of all the readers of The Popular Science Monthly has doubtless been attracted by the notices of the discovery, by M. Rivière, at several times within the last three years, of more or less complete fossil skeletons of man, deep in the floors of caverns near the town of Mentone. This town, formerly tolerably well known as a watering-place on the Mediterranean, in Italy, but near the present French boundary, bids fair to be best known to the readers of our own day in connection with the primitive history of our race, and as the sepulchre from which have been exhumed the oldest skeletal remains of representatives of the genus *Homo*. Of the first discovered and illustrated of these skeletons, as well as still the most complete, we now present an account, accompanied by a copy of the plate attached to the special monograph, by M. Rivière,[1] descriptive of it; the present account is almost confined to a critical analysis and *résumé* of the facts embodied in the monograph, the consideration of the more recent discoveries being best deferred to a future time, when the new facts will doubtless be detailed in a succeeding part of the monograph, and this course seems to be the most advisable, as no additional facts have been discovered which will essentially modify the conclusions and arguments herein urged.

The monograph referred to was anticipated, to some extent, by publication in the "Archives des Missions Scientifiques," published by the French Ministry of Public Instruction, and is itself issued as a

[1] Découverte d'un squelette humain de l'époque paléolithique dans les cavernes des Baoussé-Rousse, dites Grottes de Menton, par Emile Rivière. Avec deux photographies, par MM. Anfossi et Radiguet. Paris: J. B. Baillière et fils. Menton: chez l'auteur. 1873. The plate herewith given is a copy of one of those accompanying M. Rivière's memoir, and was engraved especially for the new edition of Prof. Dana's "Manual of Geology," to the publishers of which, Messrs. Ivison, Blakeman & Taylor, we are indebted for the use of it. 4to, 64 pp. Two plates.

first part of a work which the author hopes to be able to complete under the patronage of his government.

Nine caverns are now known to exist about Mentone; these are noticed by our author in inverse sequence to their numbers (i. e., the last, first, and so on). In the fourth (Caverne du Cavillon, or Barma du Cavillon) the skeleton was discovered, and in it the most complete explorations have been prosecuted; the entrance was blocked up till the commencement of this century; it is about 7 metres (23 feet) wide at the entrance, nearly 19 (62 feet) deep, and 15 or 16 (say 50 feet) high. The soil is composed in great part of ashes, the remains of a former cooking-place. For more than three months M. Rivière pushed his investigations, unearthing the remains of animals, shells, and bone or stone instruments, and, at last (on the 26th of March, 1872), was rewarded by uncovering a human foot, at a depth of between 6 and 7 metres (20 feet) below the original floor of the cave. Continuing uninterruptedly and with the greatest care, for eight days, his excavations, he finally exhumed almost the entire skeleton. The skeleton was recumbent on its left side, lengthwise in the cave, near the right wall, and about seven metres from the entrance; its attitude was that of repose—that of a man whom sudden and painless death might have surprised in sleep; so says M. Rivière.

The skeleton, when studied and compared with those of recent types of mankind, exhibited (so far as we can learn from the memoir) no differences other than of such kind as can be demonstrated in any large collection of skeletons of the various existing races; the height was above the average (and it is a pity that it was not compared with one that approximated it more in size than the one used in comparison); the arms, legs and feet furnished no unusual proportions, either in ratio to the body, or their own constituents—that is, forearm to humerus, lower leg to thigh, etc.; the vertebral column and ribs were normal; the skull was equally normal, save as to the orbits, whose transverse diameter was somewhat greater, and vertical less than usual; in short, as far as we can ascertain from our author, had the skeleton been found in an ordinary graveyard, no suspicion would have been entertained of its great antiquity.

But, in the superincumbent and surrounding earth (ashes) were found flint and bone instruments, and the remains of various animals which no longer exist in Europe, or are altogether extinct: among the latter (assuming the correctness of their determination) were remains of a panther (*Felis antiqua*, Gerv.), the tichorhine rhinoceros, a marmot (*Arctomys primigenia*, Gerv.), a deer (*Cervus Corsicanus*, Gerv.?), and a goat (*Capra primigenia*, Gerv). The tichorhine rhinoceros, as is well known, although now extinct, has been found embalmed—skin and all—in the ice of Siberia, and must have survived long after man had originated. The other mammals cited require further study before their specific claims can be regarded as fully established. As to those

species formerly existing in Europe, but which still live under somewhat modified forms, and restricted to other lands, are the lion, from which the *Felis spelæa* is scarcely distinguishable; the spotted hyena, with which the *Hyæna spelæa* has been identified; and the bear of the ancient caverns, which differs (so far as has been shown) only in its larger size from the common bear of Europe, and for this reason (and this only, apparently) has it been identified with the grizzly of America; and on similar grounds only (i. e., superior size) have some remains of a stag, found in the cave of Mentone, been referred to the living wapiti, or elk (*Cervus Canadensis*) of America. With reference to these, it must be remembered that the progenitors of our living forms, both in America and Europe, were appreciably larger (as has been shown by Baird for the mammals of the Carlisle cave) than their modern descendants, and the American contemporary of the stag hunted by the Mentone man was considerably larger than its living representative, and consequently than the animal living in his own land.

So far, then, as yet appears from our knowledge of the skeleton, and the forms found in association with it, it can only be regarded as very ancient from an historical (and not a geological) point of view. Its possessor lived in the midst of a fauna most of whose representatives still live in forms no more modified than are the existing races of the genus *Homo* compared with himself.

But, on the other hand, that his antiquity is great, and that he lived under conditions quite different from those which verbal history has preserved for us, appears to be indubitable; if many of his associates still live, it is under considerably modified forms, and other species coexistent with him (such especially as the tichorhine rhinoceros) ceased to exist before man had begun to record the existence of even the stranger forms of animal life; and how that man and his fellows ministered to their needs is, to some extent, made known to us by the objects of their handiwork preserved around the remains of the dead.

These were either of bone, or deer's-horns, or of stone; the former were relatively few, and are referred to by M. Rivière as arrow-heads, pins, needles, chisels, sleeking-tools, and a *bâton* of command (*sic!*) made from the principal left metacarpal of a horse, perforated, and supposed to have been carried around the neck; the stone implements were much more numerous, and represented by scrapers or graters, pins, arrow or lance heads, disks, knife-blades, and hammers. The workmanship was quite rude. The great predominance of ruminant (deer, goat) bones suggests their favorite food: that they used fire is obvious; and the numerous long bones of animals split lengthwise (and only five out of more than ten thousand were not) plainly indicated that they used the marrow.

We may now pause, review the evidence thus briefly referred to, and inquire what gain has resulted from the discovery of the fossil man of Mentone.

On the one hand, we had the evidence, in the remains of man and his workmanship, associated with all the characteristic animal remains referred to, that man—man, thinking and capable of applying his conceptions to fabrications for his uses—was contemporary with the cave animals, the tichorhine rhinoceros, and the mammoth; and, if the evidence is perfectly authentic (and no doubt has been expressed), that he was even prone to embody his conceptions in rude pictorial art. Thus, man had for some time been generally acknowledged to have existed at least as far back as can be claimed for the man of Mentone.

On the other hand, the skeletal remains of the man of that period were altogether too fragmentary to allow of any definite opinion as to his structural characteristics. The data for such opinion have now been rendered available by M. Rivière's discovery; and, although he has not yet published positive details, the negative results afforded us indicate that the fossil man was, in all respects, a typical man, perhaps even differing less from his successors in Europe than do some other existing races. It is at least very certain that he had no decided apelike characteristics. Even more! He was man to excess! The proportions of the fore limb to the hind, and of the median and distal portions of each to the proximal, so far from proving a condition intermediate between man and the apes, or embryonic or juvenile humanity, or even affinity to the negro, indicate that he was more unlike the apes in such respects than are some of the existing races; nor is this evidence rebutted by any characteristics of the skull, the dentition or otherwise, so far as the testimony allows us to judge.

So much wild speculation is rife, and enthusiastic anthropologists are so much carried away by a vague idea of some startling discovery that may be at any moment made, that a counter-irritant may not be misplaced; and, where so much prophecy has been indulged, a little from ourselves may be pardoned.

With the evidences of the existence of man specialized as much as he is now, at a period so early as he is known to have lived, it is scarcely too rash to assert that it is useless to expect to find any evidence of his simian origin in any bones exhumed in the later formations in Europe, and much less in America. And, in view of the negative results of the extensive paleontological explorations made in Europe, it is almost as unlikely that any such remains will ever be found, even in the anterior formations. The anxious may therefore contemplate with a happy serenity the explorations made, for every skeleton found, in its perfect, man-like features, will not only disprove the existence of the dreaded intermediate link, but will add to the value of the negative evidence against the existence of such a link—that is, in Europe or America. And, on theoretical considerations, this is what might be expected.

But it would be altogether too rash to predict that, because no such evidence will, in all probability, be afforded by Europe or Amer-

ica, the evidence of the intermediate link will never be furnished. Let it be remembered that the present home of the anthropoid apes is almost entirely unknown in a paleontological point of view. When Africa or Asia shall have been half as well explored as Europe, or even America, it may then be time to predict that such evidence will never be forthcoming. But it is not likely, either, that the intermediate link will be of very recent origin; it may be found to have lived in the same epoch as did the Oreodonts and Titanotheres of America, or (exact synchronism is of no account here), as the antelopes and Helladotheres which ranged in miocene days the plains where now Athens stands; possibly even then the anthropoid Pithecoid had developed far into the pithecoid Anthropoid.

But, however this may be, the anthropologist who expects to find the evidences of man in a much less specialized condition than he now exhibits, in any very recent formation, in either Europe or America, must base his speculations on something else than known facts, and even in the face of zoological and paleontological evidence. Nor is it at all likely that the being who could fabricate tools and hunt with weapons the animals that were his contemporaries could have been very much less man-like than existing man. But we are now passing the border-line of induction from facts to speculation.

MICROSCOPIC ARCHITECTS.

By Mrs. MARY TREAT.

THERE is a world of hidden beauty of which we can form no conception without the aid of the microscope. This instrument reveals a real fairy-land, of which we may sometimes have dreamed; but our wildest fancy is more than realized by the glimpses it affords of wonderfully beautiful plants and animals. Here is a world teeming with life and animation, whose inhabitants seem to possess skill and intelligence, and have worked on, unnoticed, for ages and ages.

Some of these tiny animals are architects of no mean order, building their abodes of separate bricks or pellets, laying them in tiers, as a mason or bricklayer would build a house. One of the most beautiful of these animals is the Brickmaker (*Melicerta ringens*). Fig. 1 represents it as seen with a magnifying power of 160 diameters. It was known to Leuwenhoek nearly two hundred years ago, or about the beginning of the eighteenth century. A few years later Linnæus mentions the marvelous beauty of this tiny workman, and comments upon the regularity and beauty of the house in which it dwells. If these early observers found so much to admire, with the imperfect instruments of that day, how much more are we enabled to see clearly

FIG. 1

MELICERTA RINGENS.—*a*, Apparatus for moulding brick; *b*, mouth.

the wonderful visions presented to us by the greatly improved microscopes of to-day!

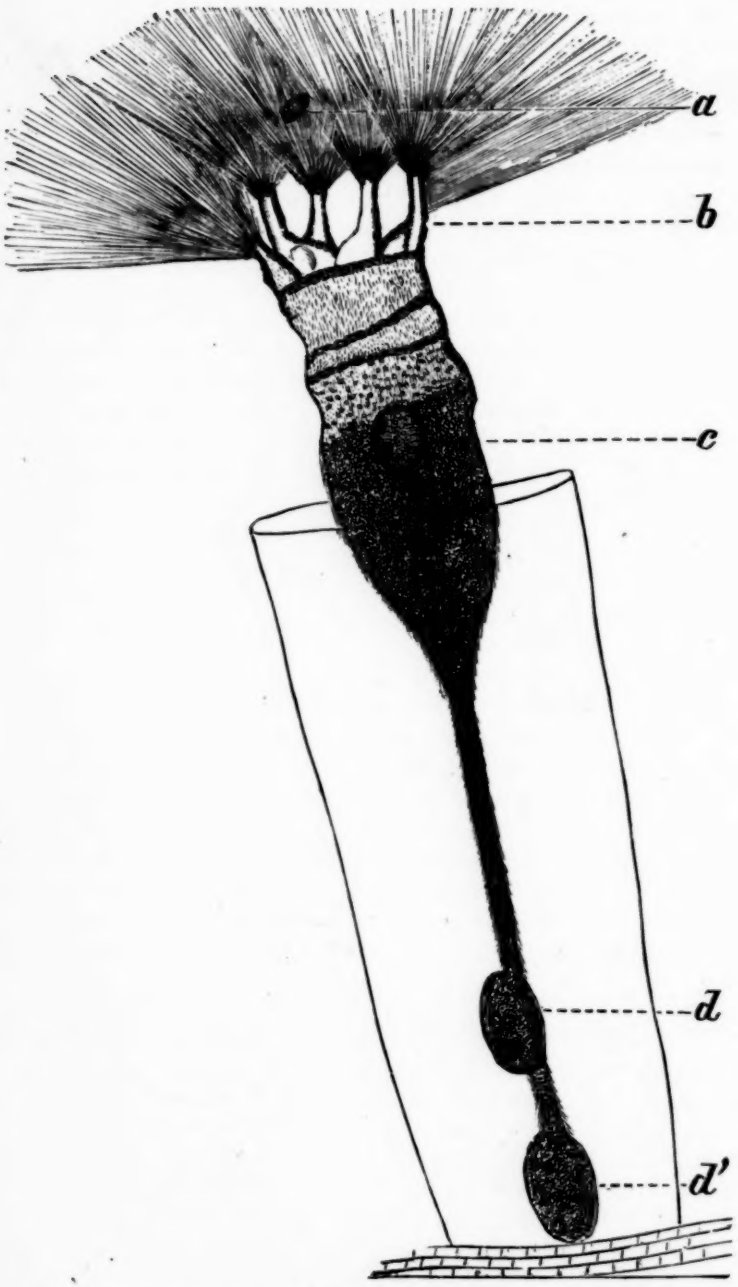
Although *Melicerta ringens* was known so long ago, yet Mr. Gosse was the first to describe the manner of its building its abode. The few who have made these microscopic creatures a study have recorded their labors in many volumes, scarcely attainable to the ordinary lover of natural history.

The animals figured and described here are as seen through a binocular microscope, with a magnifying power of 160 diameters. This power enables us to clearly define each separate brick in the tube of Melicerta, and to note the firmness and regularity of the structure. Although built of round bricks, yet it is so constructed that there are no interstices or spaces between. No bird, no other animal, not even man himself, can excel the beautiful workmanship of this tiny creature, scarcely visible to the naked eye, yet, under the microscope, assuming vast proportions. She not only builds her house, but manufactures her own brick, and lays them up one by one with no workmen to assist. The house is usually attached to some water-plant; but I have seen the young ones, upon a few occasions, anchor their dwellings to the parent-house.

When the animal is resting, or is in any way disturbed, she settles down in the lower part of the tube; but, when all is quiet and she is in good working condition, with no nursery of young ones around her, she is pretty sure to reward us with the sight of her four beautiful wheels, which she sets in rapid motion, thus forming a swift current which brings the food and the material for the brick close to her head; and she has the power of selection, for she often rejects particles brought to her mouth. The apparatus for moulding the brick is within the body. The material is brought through the action of the wheels to a small opening, where it is passed down to the apparatus, which is in rapid, whirling motion, soldering the particles together until they become, seemingly, a solid ball; now she ejects the brick from its mould, bends her head over, and securely places it on top of the structure. It takes her about three minutes to manufacture each brick.

Finding one with a tube so long that only a part of the flower-like head could appear above the battlement, I cut about one-third of the tube away, replaced it under the microscope, and watched for the reappearance of the creature. She soon came forth, and, rather hastily, rushed up beyond the decapitated story of her house until she reached her accustomed height, when she began to unfold her petal-like lobes. Now, evidently for the first time aware of something amiss, she shot back into her house much quicker than she came up. This she repeated several times before seeming to have courage to investigate; at last she set her wheels in motion, and threw herself from side to side—quite nervous-like—not seeming to relish the situation, or really

FIG. 2



FLOSCULARIA ORNATA.—*a*, Monad; *b*, lobe; *c*, mouth; *d*, egg; *d'*, egg.

to quite comprehend what the matter was with her surroundings. It was some hours before she resumed her occupation of brickmaking, and, when one was completed, it was very amusing to watch her efforts to place it; she wasted a quantity of brick before she became aware how low down she must reach in order to rebuild, but this at last she learned, and now the work was rapidly carried forward; she had placed several new tiers around her dwelling when an accident prevented my further observation. There was no difficulty in seeing where the building recommenced, for the new brick was very much lighter colored than the old.

Fig. 2 represents the beautiful Floscule. Microscopists call it *Floscularia ornata.* Like the Brickmaker, it lives in a house, a transparent, glass-like house, which I frequently find broken, sometimes entirely demolished, as if the tenant had been in some skirmish, but they seem to get along very well without a house.

The Floscule here represented was probably blessed with an amiable disposition, and had lived a peaceable life, for she was large and well developed, and had an unbroken house to dwell in, through which we could see two large eggs near the bottom. When the eggs hatch, the little animals leave their mother's house and go floating off, living a free-and-easy sort of life; but, after a few days of this wandering, gypsy kind of existence, they seem to become impressed with the graver duties of life, and settle down and set up house-keeping on their own account.

Like the Brickmaker, the Floscule has a long footstalk, which she fastens to the leaf of some water-plant, where she remains moored during the rest of her life. She seems to be a very nervous, sensitive creature; for the slightest jar upon the table, or sometimes even a step upon the floor, or the closing of a door, will quickly send her into her glass-like house, where she settles down in a heap, looking scarcely more than an animated mass of jelly. But, if all is quiet, she soon begins to unfold, stretches out her long footstalk, which pushes up her bell-shaped body, surmounted by a mass of fine bristly filaments, which look like a dense cloud of smoke issuing from the opening at the top; and, as she gradually unfolds, we see there are five lobes to which the hair-like filaments are attached, which now begin to spread out like a fan (*see* Fig. 2). As nothing is made in vain, these filaments must in some way be of use to the animal. She cannot go in search of food, for she is firmly anchored to one spot, and has no wheels to set in motion to form a current to bring food to her: so we will carefully watch and see how she captures her prey. Here comes a little floating monad. Ah, it is caught among the bristly filaments, and flies wildly about as if bewildered; but, instead of retreating and getting away, it goes down, down, until it reaches the wide opening. This opening is surmounted by the five lobes which bear the filaments, but it is not the Floscule's mouth, the

mouth is situated lower down (*see* Fig. 2), and works something like a steel-trap. Well, the little monad has got into this opening and seems to have recovered from its fright, as there is plenty of room for it to float about here; but the Floscule is now on the alert, the monad is doomed! If it tries to escape, those lobes that stand up so

FIG. 3.

CARCHESIUM POLYPINUM.—(Tree Vorticella.)

innocent-like, with their beautiful fan-shaped filaments, immediately curve over and close the opening. This movement of the Floscule usually sends the little monad close to that terrible steel-trap, when it is snapped up in a moment. Our ears are so heavy and dull, or we

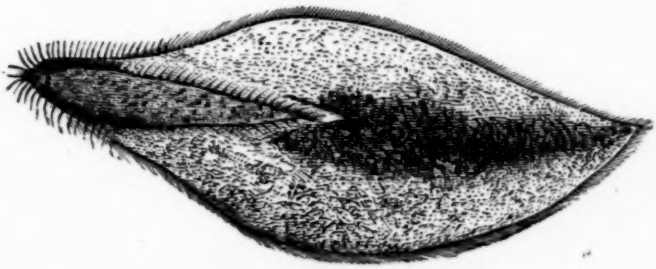
might fairly hear the click of her teeth, so large and voracious does she appear.

Sometimes an animal is betrayed into the opening too large for the Floscule to manage, and it is very amusing to watch its efforts to escape, and to see the Floscule try to devour it; she makes many attempts to take it into her mouth, but, at last, seeming to become discouraged, she opens wide the door and gives it permission to leave.

Fig. 3 introduces us to one of the most lovely of microscopic objects, the Tree Vorticella (*Carchesium polypinum*). Although this animal cannot be said to build a house, yet, in one sense, it is an architect, for a tree is built up in some way, and the little bell-shaped creatures hang on the ends of the branches, where they look more like flowers than animals. The stem of the tree is transparent and seems to be jointed, and the little creatures can swing the branches about, and even throw them into a spiral coil, so as to bring them close to the trunk of the tree. This gives them the appearance of being wonderfully polite: they bow and courtesy to each other as if preparing for a grand quadrille; and they are decked out in gay colors, red and green, and yellow, and the margin of the little cup is beautifully fringed with cilia, which are in rapid motion, producing a current which brings their food to them.

But one of the most curious sights I ever beheld was a Cyclops, with a Tree Vorticella growing on its back. It was a larger tree than here represented, and a different species; the branches were more straight, and much more numerous. Only think of it, an animal swimming about with a great tree of living freight on its back! But

FIG. 4.



PARAMECIUM CAUDATUM (Front View).

they did not seem to have much control over the Cyclops, for he dashed about as if he did not care how many he knocked overboard! But, alas! the poor Cyclops, with his strange freight, came to grief. I undertook to transfer him to the live-box, so that our artist might have him more under control, when I brought down the cover a little too close, crushing him in the operation. This sent the vorticellas flying off their stems, and all was spoiled.

Fig. 4 represents a front view of *Paramecium caudatum*. He is not an architect, but a wandering, idle sort of fellow, often seen in company with our more staid and settled house-keepers. He gets into the oddest shapes imaginable. If he is a little cramped for room it does not seem to inconvenience him in the least, for his body is so flexible he can make it fat and dumpy, or long and slender, just as the occasion seems to require. If they have any police regulations in this fairy-world, he must be a great trial to the authorities, eluding their grasp, and bowing to them from some other quarter, entirely transformed. But, when there is nothing to interfere with his locomotion, he looks very much like a leaf, as is seen in our figure. He is covered all over with rather short, stiff hairs, or cilia, that look like porcupine-quills—perhaps they are his weapons of defense. He is not carnivorous, but lives on a vegetable diet, and is so transparent that we can always tell what he has taken for his dinner. His favorite food seems to be diatoms. These are beautiful little plants encased in a shell of various forms and colors. This curious animal sometimes manages to swallow two diatoms at once, almost as long as his body, and then he seems rather awkward and stiff, with two great logs on his stomach! But he manages, somehow, to absorb the nutritious, vegetable part of the diatom, and throws aside the beautiful transparent shell, which he has not broken nor injured at all in the operation.

INAUGURAL ADDRESS BEFORE THE BRITISH ASSOCIATION.

By Prof. JOHN TYNDALL, D. C. L., LL. D., F. R. S., President.

AN impulse inherent in primeval man turned his thoughts and questionings betimes toward the sources of natural phenomena. The same impulse, inherited and intensified, is the spur of scientific action to-day. Determined by it, by a process of abstraction from experience we form physical theories which lie beyond the pale of experience, but which satisfy the desire of the mind to see every natural occurrence resting upon a cause. In forming their notions of the origin of things, our earliest historic (and doubtless, we might add, our prehistoric) ancestors pursued, as far as their intelligence permitted, the same course. They also fell back upon experience, but with this difference—that the particular experiences which furnished the weft and woof of their theories were drawn, not from the study of Nature, but from what lay much closer to them, the observation of men. Their theories accordingly took an anthropomorphic form. To supersensual beings, which, "however potent and invisible, were nothing but a

species of human creatures, perhaps raised from among mankind, and retaining all human passions and appetites,"[1] were handed over the rule and governance of natural phenomena.

Tested by observation and reflection, these early notions failed in the long-run to satisfy the more penetrating intellects of our race. Far in the depths of history we find men of exceptional power differentiating themselves from the crowd, rejecting these anthropomorphic notions, and seeking to connect natural phenomena with their physical principles. But, long prior to these purer efforts of the understanding, the merchant had been abroad, and rendered the philosopher possible: commerce had been developed, wealth amassed, leisure for travel and for speculation secured, while races educated under different conditions, and therefore differently informed and endowed, had been stimulated and sharpened by mutual contact. In those regions where the commercial aristocracy of ancient Greece mingled with its Eastern neighbors, the sciences were born, being nurtured and developed by free-thinking and courageous men. The state of things to be displaced may be gathered from a passage of Euripides quoted by Hume: "There is nothing in the world; no glory, no prosperity. The gods toss all into confusion; mix every thing with its reverse, that all of us, from our ignorance and uncertainty, may pay them the more worship and reverence." Now, as science demands the radical extirpation of caprice and the absolute reliance upon law in Nature, there grew with the growth of scientific notions a desire and determination to sweep from the field of theory this mob of gods and demons, and to place natural phenomena on a basis more congruent with themselves.

The problem which had been previously approached from above was now attacked from below; theoretic effort passed from the super- to the sub-sensible. It was felt that to construct the universe in idea it was necessary to have some notion of its constituent parts—of what Lucretius subsequently called the "First Beginnings." Abstracting again from experience, the leaders of scientific speculation reached at length the pregnant doctrine of atoms and molecules, the latest developments of which were set forth with such power and clearness at the last meeting of the British Association. Thought no doubt had long hovered about this doctrine before it attained the precision and completeness which it assumed in the mind of Democritus,[2] a philosopher who may well for a moment arrest our attention. "Few great men," says Lange, in his excellent "History of Materialism," a work to the spirit and the letter of which I am equally indebted, "have been so despitefully used by history as Democritus. In the distorted images sent down to us through unscientific traditions there remains of him almost nothing but the name of the 'laughing philosopher,' while figures of immeasurably smaller significance spread themselves

[1] Hume, "Natural History of Religion."

[2] Born 460 B. C.

at full length before us." Lange speaks of Bacon's high appreciation of Democritus—for ample illustrations of which I am indebted to my excellent friend Mr. Spedding, the learned editor and biographer of Bacon. It is evident, indeed, that Bacon considered Democritus to be a man of weightier metal than either Plato or Aristotle, though their philosophy "was noised and celebrated in the schools, amid the din and pomp of professors." It was not they, but Genseric and Attila and the barbarians, who destroyed the atomic philosophy. "For, at a time when all human learning had suffered shipwreck, these planks of Aristotelian and Platonic philosophy, as being of a lighter and more inflated substance, were preserved and come down to us, while things more solid sank and almost passed into oblivion."

The principles enunciated by Democritus reveal his uncompromising antagonism to those who deduced the phenomena of Nature from the caprices of the gods. They are briefly these: 1. From nothing comes nothing. Nothing that exists can be destroyed. All changes are due to the combination and separation of molecules. 2. Nothing happens by chance. Every occurrence has its cause from which it follows by necessity. 3. The only existing things are the atoms and empty space; all else is mere opinion. 4. The atoms are infinite in number, and infinitely various in form; they strike together, and the lateral motions and whirlings which thus arise are the beginnings of worlds. 5. The varieties of all things depend upon the varieties of their atoms, in number, size, and aggregation. 6. The soul consists of free, smooth, round atoms, like those of fire. These are the most mobile of all. They interpenetrate the whole body, and in their motions the phenomena of life arise. Thus the atoms of Democritus are individually without sensation; they combine in obedience to mechanical laws; and not only organic forms, but the phenomena of sensation and thought, are also the result of their combination.

That great enigma, "the exquisite adaptation of one part of an organism to another part, and to the conditions of life," more especially the construction of the human body, Democritus made no attempt to solve. Empedocles, a man of more fiery and poetic nature, introduced the notion of love and hate among the atoms to account for their combination and separation. Noticing this gap in the doctrine of Democritus, he struck in with the penetrating thought, linked, however, with some wild speculation, that it lay in the very nature of those combinations which were suited to their ends (in other words, in harmony with their environment) to maintain themselves, while unfit combinations, having no proper habitat, must rapidly disappear. Thus more than two thousand years ago the doctrine of the "survival of the fittest," which in our day, not on the basis of vague conjecture, but of positive knowledge, has been raised to such extraordinary significance, had received at all events partial enunciation.[1]

[1] Lange, 2d edit., p. 28

Epicurus,[1] said to be the son of a poor school-master at Samos, is the next dominant figure in the history of the atomic philosophy. He mastered the writings of Democritus, heard lectures in Athens, returned to Samos, and subsequently wandered through various countries. He finally returned to Athens, where he bought a garden, and surrounded himself by pupils, in the midst of whom he lived a pure and serene life, and died a peaceful death. His philosophy was almost identical with that of Democritus; but he never quoted either friend or foe. One main object of Epicurus was to free the world from superstition and the fear of death. Death he treated with indifference. It merely robs us of sensation. As long as we are, death is not; and when death is, we are not. Life has no more evil for him who has made up his mind that it is no evil not to live. He adored the gods, but not in the ordinary fashion. The idea of divine power, properly purified, he thought an elevating one. Still he taught, "Not he is godless who rejects the gods of the crowd, but rather he who accepts them." The gods were to him eternal and immortal beings, whose blessedness excluded every thought of care or occupation of any kind. Nature pursues her course in accordance with everlasting laws, the gods never interfering. They haunt

> "The lucid interspace of world and world
> Where never creeps a cloud or moves a wind,
> Nor ever falls the least white star of snow,
> Nor ever lowest roll of thunder moans,
> Nor sound of human sorrow mounts to mar
> Their sacred everlasting calm."[2]

Lange considers the relation of Epicurus to the gods subjective; the indication probably of an ethical requirement of his own nature. We cannot read history with open eyes, or study human nature to its depths, and fail to discern such a requirement. Man never has been, and he never will be satisfied with the operations and products of the understanding alone; hence physical science cannot cover all the demands of his nature. But the history of the efforts made to satisfy these demands might be broadly described as a history of errors—the error consisting in ascribing fixity to that which is fluent, which varies as we vary, being gross when we are gross, and becoming, as our capacities widen, more abstract and sublime. On one great point the mind of Epicurus was at peace. He neither sought nor expected, here or hereafter, any personal profit from his relation to the gods. And it is assuredly a fact that loftiness and serenity of thought may be promoted by conceptions which involve no idea of profit of this kind. "Did I not believe," said a great man to me once, "that an Intelligence is at the heart of things, my life on earth would be intolerable." The utterer of these words is not, in my opinion, rendered less noble but more noble, by the fact that it was the need of ethical harmony

[1] Born 342 B. C.

[2] Tennyson's "Lucretius."

here, and not the thought of personal profit hereafter, that prompted his observation.

A century and a half after the death of Epicurus, Lucretius[1] wrote his great poem, "On the Nature of Things," in which he, a Roman, developed with extraordinary ardor the philosophy of his Greek predecessor. He wishes to win over his friend Memnius to the school of Epicurus; and although he has no rewards in a future life to offer, although his object appears to be a purely negative one, he addresses his friend with the heat of an apostle. His object, like that of his great forerunner, is the destruction of superstition; and considering that men trembled before every natural event as a direct monition from the gods, and that everlasting torture was also in prospect, the freedom aimed at by Lucretius might perhaps be deemed a positive good. "This terror," he says, "and darkness of mind must be dispelled, not by the rays of the sun and glittering shafts of day, but by the aspect and the law of Nature." He refutes the notion that any thing can come out of nothing, or that that which is once begotten can be recalled to nothing. The first beginnings, the atoms, are indestructible, and into them all things can be dissolved at last. Bodies are partly atoms and partly combinations of atoms; but the atoms nothing can quench. They are strong in solid singleness, and by their denser combination all things can be closely packed and exhibit enduring strength. He denies that matter is infinitely divisible. We come at length to the atoms, without which, as an imperishable substratum, all order in the generation and development of things would be destroyed.

The mechanical shock of the atoms being in his view the all-sufficient cause of things, he combats the notion that the constitution of Nature has been in any way determined by intelligent design. The interaction of the atoms throughout infinite time rendered all manner of combinations possible. Of these the fit ones persisted, while the unfit ones disappeared. Not after sage deliberation did the atoms station themselves in their right places, nor did they bargain what motions they should assume. From all eternity they have been driven together, and, after trying motions and unions of every kind, they fell at length into the arrangements out of which this system of things has been formed. His grand conception of the atoms falling silently through immeasurable ranges of space and time suggested the nebular hypothesis to Kant, its first propounder. "If you will apprehend and keep in mind these things, Nature, free at once, and rid of her haughty lords, is seen to do all things spontaneously of herself, without the meddling of the gods."[2]

[1] Born 99 B. C.

[2] Monro's translation. In his criticism of this work (*Contemporary Review*, 1867) Dr. Hayman does not appear to be aware of the really sound and subtile observations on which the reasoning of Lucretius, though erroneous, sometimes rests.

During the centuries between the first of these three philosophers and the last, the human intellect was active in other fields than theirs. The Sophists had run through their career. At Athens had appeared the three men, Socrates, Plato, and Aristotle, whose yoke remains to some extent unbroken to the present hour. Within this period, also, the School of Alexandria was founded, Euclid wrote his "Elements," and he and others made some advance in optics. Archimedes had propounded the theory of the lever and the principles of hydrostatics. Pythagoras had made his experiments on the harmonic intervals, while astronomy was immensely enriched by the discoveries of Hipparchus, who was followed by the historically more celebrated Ptolemy. Anatomy had been made the basis of scientific medicine; and it is said by Draper[1] that vivisection then began. In fact, the science of ancient Greece had already cleared the world of the fantastic images of divinities operating capriciously through natural phenomena. It had shaken itself free from that fruitless scrutiny "by the internal light of the mind alone," which had vainly sought to transcend experience and reach a knowledge of ultimate causes. Instead of accidental observation, it had introduced observation with a purpose; instruments were employed to aid the senses; and scientific method was rendered in a great measure complete by the union of induction and experiment.

What, then, stopped its victorious advance? Why was the scientific intellect compelled, like an exhausted soil, to lie fallow for nearly two millenniums before it could regather the elements necessary to its fertility and strength? Bacon has already let us know one cause; Whewell ascribes this stationary period to four causes—obscurity of thought, servility, intolerance of disposition, enthusiasm of temper; and he gives striking examples of each.[2] But these characteristics must have had their causes, which lay in the circumstances of the time. Rome and the other cities of the empire had fallen into moral putrefaction. Christianity had appeared, offering the Gospel to the poor, and, by moderation if not asceticism of life, practically protesting against the profligacy of the age. The sufferings of the early Christians and the extraordinary exaltation of mind which enabled them to triumph over the diabolical tortures to which they were subjected,[3] must have left traces not easily effaced. They scorned the earth, in view of that "building of God, that house not made with hands, eternal in the heavens." The Scriptures which ministered to their spiritual needs were also the measure of their science. When, for example, the celebrated question of antipodes came to be discussed, the Bible was with many the ultimate court of appeal. Augustine, who flourished A. D. 400, would not deny the rotundity of the earth,

[1] "History of the Intellectual Development of Europe," p. 295.

[2] "History of the Inductive Sciences," vol. i.

[3] Depicted with terrible vividness in Rénan's "Antichrist."

but he would deny the possible existence of inhabitants at the other side, "because no such race is recorded in Scripture among the descendants of Adam." Archbishop Boniface was shocked at the assumption of a "world of human beings out of the reach of the means of salvation." Thus reined in, science was not likely to make much progress. Later on, the political and theological strife between the Church and civil governments, so powerfully depicted by Draper, must have done much to stifle investigation.

Whewell makes many wise and brave remarks regarding the spirit of the middle ages. It was a menial spirit. The seekers after natural knowledge had forsaken that fountain of living waters, the direct appeal to Nature by observation and experiment, and had given themselves up to the remanipulation of the notions of their predecessors. It was a time when thought had become abject, and when the acceptance of mere authority led, as it always does in science, to intellectual death. Natural events, instead of being traced to physical, were referred to moral causes, while an exercise of the fantasy, almost as degrading as the spiritualism of the present day, took the place of scientific speculation. Then came the mysticism of the middle ages, magic, alchemy, the Neo-platonic philosophy, with its visionary though sublime attractions, which caused men to look with shame upon their own bodies as hindrances to the absorption of the creature in the blessedness of the Creator. Finally came the scholastic philosophy, a fusion, according to Lange, of the least mature notions of Aristotle with the Christianity of the West. Intellectual immobility was the result. As a traveler without a compass in a fog may wander long, imagining he is making way, and find himself, after hours of toil, at his starting-point, so the schoolmen, having tied and untied the same knots, and formed and dissipated the same clouds, found themselves at the end of centuries in their old position.

With regard to the influence wielded by Aristotle in the middle ages, and which, though to a less extent, he still wields, I would ask permission to make one remark. When the human mind has achieved greatness and given evidence of extraordinary power in any domain, there is a tendency to credit it with similar power in all other domains. Thus theologians have found comfort and assurance in the thought that Newton dealt with the question of revelation, forgetful of the fact that the very devotion of his powers, through all the best years of his life, to a totally different class of ideas, not to speak of any natural disqualification, tended to render him less instead of more competent to deal with theological and historic questions. Goethe, starting from his established greatness as a poet, and indeed from his positive discoveries in natural history, produced a profound impression among the painters of Germany when he published his "Farbenlehre," in which he endeavored to overthrow Newton's theory of colors. This theory he deemed so obviously absurd, that he considered

its author a charlatan, and attacked him with a corresponding vehemence of language. In the domain of natural history Goethe had made really considerable discoveries; and we have high authority for assuming that, had he devoted himself wholly to that side of science, he might have reached in it an eminence comparable with that which he attained as a poet. In sharpness of observation, in the detection of analogies, however apparently remote, in the classification and organization of facts according to the analogies discerned, Goethe possessed extraordinary powers. These elements of scientific inquiry fall in with the discipline of the poet. But, on the other hand, a mind thus richly endowed in the direction of natural history may be almost shorn of endowment as regards the more strictly called physical and mechanical sciences. Goethe was in this condition. He could not formulate distinct mechanical conceptions; he could not see the force of mechanical reasoning; and in regions where such reasoning reigns supreme he became a mere *ignis fatuus* to those who followed him.

I have sometimes permitted myself to compare Aristotle with Goethe, to credit the Stagirite with an almost superhuman power of amassing and systematizing facts, but to consider him fatally defective on that side of the mind in respect to which incompleteness has been justly ascribed to Goethe. Whewell refers the errors of Aristotle, not to a neglect of facts, but to "a neglect of the idea appropriate to the facts; the idea of mechanical cause, which is force, and the substitution of vague or inapplicable notions, involving only relations of space or emotions of wonder." This is doubtless true; but the word "neglect" implies mere intellectual misdirection, whereas in Aristotle, as in Goethe, it was not, I believe, misdirection, but sheer natural incapacity which lay at the root of his mistakes. As a physicist, Aristotle displayed what we should consider some of the worst attributes of a modern physical investigator—indistinctness of ideas, confusion of mind, and a confident use of language, which led to the delusive notion that he had really mastered his subject, while he as yet had failed to grasp even the elements of it. He put words in the place of things, subject in the place of object. He preached induction without practising it, inverting the true order of inquiry by passing from the general to the particular, instead of from the particular to the general. He made of the universe a closed sphere, in the centre of which he fixed the earth, proving from general principles, to his own satisfaction and that of the world for nearly 2,000 years, that no other universe was possible. His notions of motion were entirely unphysical. It was natural or unnatural, better or worse, calm or violent —no real mechanical conception regarding it lying at the bottom of his mind. He affirmed that a vacuum could not exist, and proved that if it did exist motion in it would be impossible. He determined *a priori* how many species of animals must exist, and showed on gen-

eral principles why animals must have such and such parts. When an eminent contemporary philosopher, who is far removed from errors of this kind, remembers these abuses of the *a priori* method, he will be able to make allowance for the jealousy of physicists as to the acceptance of so-called *a priori* truths. Aristotle's errors of detail were grave and numerous. He affirmed that only in man we had the beating of the heart, that the left side of the body was colder than the right, that men have more teeth than women, and that there is an empty space, not at the front, but at the back of every man's head.

There is one essential quality in physical conceptions which was entirely wanting in those of Aristotle and his followers. I wish it could be expressed by a word untainted by its associations; it signifies a capability of being placed as a coherent picture before the mind. The Germans express the act of picturing by the word *vorstellen*, and the picture they call a *Vorstellung*. We have no word in English which comes nearer to our requirements than *imagination*, and, taken with its proper limitations, the word answers very well; but, as just intimated, it is tainted by its associations, and therefore objectionable to some minds. Compare, with reference to this capacity of mental presentation, the case of the Aristotelian, who refers the ascent of water in a pump to Nature's abhorrence of a vacuum, with that of Pascal when he proposed to solve the question of atmospheric pressure by the ascent of the Puy de Dôme. In the one case the terms of the explanation refuse to fall into place as a physical image; in the other the image is distinct, the fall and rise of the barometer being clearly figured as the balancing of two varying and opposing pressures.

During the drought of the middle ages in Christendom, the Arabian intellect, as forcibly shown by Draper, was active. With the intrusion of the Moors into Spain, cleanliness, order, learning, and refinement, took the place of their opposites. When smitten with the disease, the Christian peasant resorted to a shrine; the Moorish one to an instructed physician. The Arabs encouraged translations from the Greek philosophers, but not from the Greek poets. They turned in disgust "from the lewdness of our classical mythology, and denounced as an unpardonable blasphemy all connection between the impure Olympian Jove and the Most High God." Draper traces still further than Whewell the Arab elements in our scientific terms, and points out that the under-garment of ladies retains to this hour its Arab name. He gives examples of what Arabian men of science accomplished, dwelling particularly on Alhazen, who was the first to correct the Platonic notion that rays of light are emitted by the eye. He discovered atmospheric refraction, and points out that we see the sun and moon after they have set. He explains the enlargement of the sun and moon, and the shortening of the vertical diameters of both

these bodies, when near the horizon. He is aware that the atmosphere decreases in density with increase of height, and actually fixes its height at 58½ miles. In the "Book of the Balance Wisdom," he sets forth the connection between the weight of the atmosphere and its increasing density. He shows that a body will weigh differently in a rare and a dense atmosphere. He considers the force with which plunged bodies rise through heavier media. He understands the doctrine of the centre of gravity, and applies it to the investigation of balances and steelyards. He recognizes gravity as a force, though he falls into the error of making it diminish at the distance, and of making it purely terrestrial. He knows the relation between the velocities, spaces, and times of falling bodies, and has distinct ideas of capillary attraction. He improves the hydrometer. The determination of the densities of the bodies, as given by Alhazen, approaches very closely to our own. "I join," says Draper, "in the pious prayer of Alhazen, 'that in the day of judgment the All-Merciful will take pity on the soul of Abur-Raihân, because he was the first of the race of men to construct a table of specific gravities.'" If all this be historic truth (and I have entire confidence in Dr. Draper), well may he "deplore the systematic manner in which the literature of Europe has contrived to put out of sight our scientific obligations to the Mohammedans."[1]

Toward the close of the stationary period, a word-weariness, if I may so express it, took more and more possession of men's minds. Christendom had become sick of the school philosophy and its verbal wastes, which led to no issue, but left the intellect in everlasting haze. Here and there was heard the voice of one impatiently crying in the wilderness, "Not unto Aristotle, not unto subtile hypotheses, not unto Church, Bible, or blind tradition, must we turn for a knowledge of the universe, but to the direct investigation of Nature by observation and experiment." In 1543 the epoch-making work of Copernicus on the paths of the heavenly bodies appeared. The total crash of Aristotle's closed universe with the earth at its centre followed as a consequence; and "the earth moves" became a kind of watchword among intellectual freemen. Copernicus was the Canon of the Church of Frauenburg, in the diocese of Ermeland. For three-and-thirty years he had withdrawn himself from the world, and devoted himself to the consolidation of his great scheme of the solar system. He made its blocks eternal; and even to those who feared it, and desired its overthrow, it was so obviously strong that they refrained from meddling with it. In the last year of the life of Copernicus his book appeared. It is said that the old man received a copy of it a few days before his death, and then departed in peace.

The Italian philosopher Giordano Bruno was one of the earliest converts to the new astronomy. Taking Lucretius as his exemplar,

[1] "Intellectual Development of Europe," p. 359.

he revived the notion of the infinity of worlds; and, combining with it the doctrine of Copernicus, reached the sublime generalization that the fixed stars are suns, scattered numberless through space and accompanied by satellites, which bear the same relation to them as the earth does to our sun, or our moon to our earth. This was an expansion of transcendent import; but Bruno came closer than this to our present line of thought. Struck with the problem of the generation and maintenance of organisms, and duly pondering it, he came to the conclusion that Nature in her productions does not imitate the technic of man. Her process is one of unraveling and unfolding. The infinity of forms under which matter appears was not imposed upon it by an external artificer; by its own intrinsic force and virtue it brings these forms forth. Matter is not the mere naked, empty *capacity* which philosophers have pictured her to be, but the universal mother, who brings forth all things as the fruit of her own womb.

This outspoken man was originally a Dominican monk. He was accused of heresy and had to fly, seeking refuge in Geneva, Paris, England, and Germany. In 1592 he fell into the hands of the Inquisition at Venice. He was imprisoned for many years, tried, degraded, excommunicated, and handed over to the civil power, with the request that he should be treated gently and "without the shedding of blood." This meant that he was to be burnt; and burnt accordingly he was, on February 16, 1600. To escape a similar fate, Galileo, thirty-three years afterward, abjured, upon his knees and with his hand on the holy gospels, the heliocentric doctrine. After Galileo came Kepler, who from his German home defied the power beyond the Alps. He traced out from preëxisting observations the laws of planetary motion. The problem was thus prepared for Newton, who bound those empirical laws together by the principle of gravitation.

During the middle ages the doctrine of atoms had to all appearance vanished from discussion. In all probability it held its ground among sober-minded and thoughtful men, though neither the Church nor the world was prepared to hear of it with tolerance. Once, in the year 1348, it received distinct expression. But retraction by compulsion immediately followed, and, thus discouraged, it slumbered till the seventeenth century, when it was revived by a contemporary of Hobbes and Descartes, the Père Gassendi.

The analytic and synthetic tendencies of the human mind exhibit themselves throughout history, great writers ranging themselves sometimes on the one side, sometimes on the other. Men of lofty feelings, and minds open to the elevating impressions produced by Nature as a whole, whose satisfaction, therefore, is rather ethical than logical, have leaned to the synthetic side; while the analytic harmonizes best with the more precise and more mechanical bias which seeks the satisfaction of the understanding. Some form of pantheism was usually adopted by the one, while a detached Creator, working more or less after the

manner of men, was often assumed by the other.[1] Gassendi is hardly to be ranked with either. Having formerly acknowledged God as the first great cause, he immediately drops the idea, applies the known laws of mechanics to the atoms, and thence deduces all vital phenomena. God, who created earth and water, plants and animals, produced in the first place a definite number of atoms, which constituted the seed of all things. Then began that series of combinations and decompositions which goes on at the present day, and which will continue in the future. The principle of every change resides in matter. In artificial productions the moving principle is different from the material worked upon; but in Nature the agent works within, being the most active and mobile part of the material itself. Thus this bold ecclesiastic, without incurring the censure of the Church or the world, contrives to outstrip Mr. Darwin. The same cast of mind which caused him to detach the Creator from his universe led him also to detach the soul from the body, though to the body he ascribes an influence so large as to render the soul almost unnecessary. The aberrations of reason were in his view an affair of the material brain. Mental disease is brain-disease; but then the immortal reason sits apart, and cannot be touched by the disease. The errors of madness are errors of the instrument, not of the performer.

It may be more than a mere result of education, connecting itself probably with the deeper mental structure of the two men, that the idea of Gassendi, above enunciated, is substantially the same as that expressed by Prof. Clerk Maxwell at the close of the very noble lecture delivered by him at Bradford last year. According to both philosophers, the atoms, if I understand aright, are the *prepared materials*, the "manufactured articles," which, formed by the skill of the Highest, produce by their subsequent interaction all the phenomena of the material world. There seems to be this difference, however, between Gassendi and Maxwell: the one *postulates*, the other *infers* his first cause. In his manufactured articles, Prof. Maxwell finds the basis of an induction which enables him to scale philosophic heights considered inaccessible by Kant, and to take the logical step from the atoms to their Maker.

The atomic doctrine, in whole or in part, was entertained by Bacon, Descartes, Hobbes, Locke, Newton, Boyle, and their successors, until the chemical law of multiple proportions enabled Dalton to confer upon it an entirely new significance. In our day there are secessions from the theory, but it still stands firm. Only a year or two ago Sir William Thomson, with characteristic penetration, sought

[1] Boyle's model of the universe was the Strasbourg clock with an outside artificer. Goethe, on the other hand, sang:

"Ihm ziemt's die Welt im Innern zu bewegen,
Natur in sich, sich in Natur zu hegen."

The same repugnance to the clockmaker conception is manifest in Carlyle.

to determine the sizes of the atoms, or rather to fix the limits between which their sizes lie; while only last year the discourses of Williamson and Maxwell illustrate the present hold of the doctrine upon the foremost scientific minds. What these atoms, self-moved and self-posited, can and cannot accomplish in relation to life, is at the present moment the subject of profound scientific thought. I doubt the legitimacy of Maxwell's logic; but it is impossible not to feel the ethic glow with which his lecture concludes. There is, moreover, a Lucretian grandeur in his description of the steadfastness of the atoms: "Natural causes, as we know, are at work, which tend to modify, if they do not at length destroy, all the arrangements and dimensions of the earth and the whole solar system. But though in the course of ages catastrophes have occurred and may yet occur in the heavens, though ancient systems may be dissolved and new systems evolved out of their ruins, the molecules out of which these systems are built, the foundation-stones of the material universe, remain unbroken and unworn."

Ninety years subsequent to Gassendi the doctrine of bodily instruments, as it may be called, assumed immense importance in the hands of Bishop Butler, who, in his famous "Analogy of Religion," developed, from his own point of view, and with consummate sagacity, a similar idea. The bishop still influences superior minds; and it will repay us to dwell for a moment on his views. He draws the sharpest distinction between our real selves and our bodily instruments. He does not, as far as I remember, use the word soul, possibly because the term was so hackneyed in his day, as it had been for many generations previously. But he speaks of "living powers," "perceiving" or "percipient powers," "moving agents," "ourselves," in the same sense as we should employ the term soul. He dwells upon the fact that limbs may be removed and mortal diseases assail the body, while the mind, almost, up to the moment of death, remains clear. He refers to sleep and to swoon, where the "living powers" are suspended but not destroyed. He considers it quite as easy to conceive of an existence out of our bodies as in them; that we may animate a succession of bodies, the dissolution of all of them having no more tendency to dissolve our real selves, or "deprive us of living faculties—the faculties of perception and action—than the dissolution of any foreign matter which we are capable of receiving impressions from, or making use of, for the common occasions of life." This is the key of the bishop's position: "Our organized bodies are no more a part of ourselves than any other matter around us." In proof of this he calls attention to the use of glasses, which "prepare objects" for the "percipient power" exactly as the eye does. The eye itself is no more percipient than the glass, and is quite as much the instrument of the true self, and also as foreign to the true self, as the glass is. "And if we see with our eyes only in the same manner as we do with

glasses, the like may justly be concluded from analogy of all our senses."

Lucretius, as you are aware, reached a precisely opposite conclusion; and it certainly would be interesting, if not profitable, to us all, to hear what he would or could urge in opposition to the reasoning of the bishop. As a brief discussion of the point will enable us to see the bearings of an important question, I will here permit a disciple of Lucretius to try the strength of the bishop's position, and then allow the bishop to retaliate, with the view of rolling back, if he can, the difficulty upon Lucretius. Each shall state his case fully and frankly, and you shall be umpire between them. The argument might proceed in this fashion:

"Subjected to the test of mental presentation (*Vorstellung*) your views, most honored prelate, would present to many minds a great, if not an insuperable difficulty. You speak of 'living powers,' 'percipient or perceiving powers,' and 'ourselves;' but can you form a mental picture of any one of these apart from the organism through which it is supposed to act? Test yourself honestly, and see whether you possess any faculty that would enable you to form such a conception. The true self has a local habitation in each of us; thus localized, must it not possess a form? If so, what form? Have you ever for a moment realized it? When a leg is amputated, the body is divided into two parts; is the true self in both of them or in one? Thomas Aquinas might say in both; but not you, for you appeal to the consciousness associated with one of the two parts to prove that the other is foreign matter. Is consciousness, then, a necessary element of the true self? If so, what do you say to the case of the whole body being deprived of consciousness? If not, then on what grounds do you deny any portion of the true self to the severed limb? It seems very singular that, from the beginning to the end of your admirable book (and no one admires its sober strength more than I do), you never once mention the brain or nervous system. You begin at one end of the body, and show that its parts may be removed without prejudice to the perceiving power. What if you begin at the other end, and remove, instead of the leg, the brain? The body, as before, is divided into two parts; but both are now in the same predicament, and neither can be appealed to to prove that the other is foreign matter. Or, instead of going so far as to remove the brain itself, let a certain portion of its bony covering be removed, and let a rhythmic series of pressure and relaxations of pressure be applied to the soft substance. At every pressure 'the faculties of perception and of action' vanish; at every relaxation of pressure they are restored. Where, during the intervals of pressure, is the perceiving power? I once had the discharge of a Leyden battery passed unexpectedly through me: I felt nothing, but was simply blotted out of conscious existence for a sensible interval. Where was my true self during that interval? Men

who have recovered from lightning-stroke have been much longer in the same state; and, indeed, in cases of ordinary concussion of the brain, days may elapse during which no experience is registered in consciousness. Where is the man himself during the period of insensibility? You may say that I beg the question when I assume the man to have been unconscious, that he was really conscious all the time, and has simply forgotten what had occurred to him. In reply to this, I can only say that no one need shrink from the worst tortures that superstition ever invented if only so felt and so remembered. I do not think your theory of instruments goes at all to the bottom of the matter. A telegraph operator has his instruments, by means of which he converses with the world; our bodies possess a nervous system, which plays a similar part between the perceiving powers and external things. Cut the wires of the operator, break his battery, demagnetize his needle; by this means you certainly sever his connection with the world; but, inasmuch as these are real instruments, their destruction does not touch the man who uses them. The operator survives, *and he knows that he survives.* What is it, I would ask, in the human system that answers to this conscious survival of the operator when the battery of the brain is so disturbed as to produce insensibility, or when it is destroyed altogther?

"Another consideration, which you may consider slight, presses upon me with some force. The brain may change from health to disease, and through such a change the most exemplary man may be converted into a debauchee or a murderer. My very noble and approved good master had, as you know, threatenings of lewdness introduced into his brain by his jealous wife's philter; and, sooner than permit himself to run even the risk of yielding to these base promptings, he slew himself. How could the hand of Lucretius have been thus turned against himself if the real Lucretius remained as before? Can the brain or can it not act in this distempered way without the intervention of the immortal reason? If it can, then it is a prime mover which requires only healthy regulation to render it reasonably self-acting, and there is no apparent need of your immortal reason at all. If it cannot, then the immortal reason, by its mischievous activity in operating upon a broken instrument, must have the credit of committing every imaginable extravagance and crime. I think, if you will allow me to say so, that the gravest consequences are likely to flow from your estimate of the body. To regard the brain as you would a staff or an eyeglass—to shut your eyes to all its mystery, to the perfect correlation that reigns between its condition and our consciousness, to the fact that a slight excess or defect of blood in it produces that very swoon to which you refer, and that in relation to it our meat and drink and air and exercise have a perfectly transcendental value and significance—to forget all this does, I think, open a way to innumerable errors in our habits of life, and may possibly in some cases initiate

and foster that very disease, and consequent mental ruin, which a wiser appreciation of this mysterious organ would have avoided."

I can imagine the bishop thoughtful after hearing this argument. He was not the man to allow anger to mingle with the consideration of a point of this kind. After due consideration, and having strengthened himself by that honest contemplation of the facts which was habitual with him, and which includes the desire to give even adverse facts their due weight, I can suppose the bishop to proceed thus: "You will remember that in the 'Analogy of Religion,' of which you have so kindly spoken, I did not profess to prove any thing absolutely, and that I over and over again acknowledged and insisted on the smallness of our knowledge, or rather the depth of our ignorance, as regards the whole system of the universe. My object was to show my deistical friends who set forth so eloquently the beauty and beneficence of Nature and the Ruler thereof, while they had nothing but scorn for the so-called absurdities of the Christian scheme, that they were in no better condition than we were, and that for every difficulty they found upon our side, quite as great a difficulty was to be found on theirs. I will now, with your permission, adopt a similar line of argument. You are a Lucretian, and from the combination and separation of atoms deduce all terrestrial things, including organic forms and their phenomena. Let me tell you in the first instance how far I am prepared to go with you. I admit that you can build crystalline forms out of this play of molecular force; that the diamond, amethyst, and snow-star, are truly wonderful structures which are thus produced. I will go further and acknowledge that even a tree or flower might in this way be organized. Nay, if you can show me an animal without sensation, I will concede to you that it also might be put together by the suitable play of molecular force.

"Thus far our way is clear, but now comes my difficulty. Your atoms are individually without sensation, much more are they without intelligence. May I ask you, then, to try your hand upon this problem? Take your dead hydrogen-atoms, your dead oxygen-atoms, your dead carbon-atoms, your dead nitrogen-atoms, your dead phosphorus-atoms, and all the other atoms, dead as grains of shot, of which the brain is formed. Imagine them separate and sensationless; observe them running together and forming all imaginable combinations. This, as a purely mechanical process, is *seeable* by the mind. But can you see, or dream, or in any way imagine, how out of that mechanical act, and from these individually dead atoms, sensation, thought, and emotion, are to arise? You speak of the difficulty of presentation in my case; is it less in yours? I am not all bereft of this *Vorstellungskraft* of which you speak. I can follow a particle of musk until it reaches the olfactory nerve; I can follow the waves of sound until their tremors reach the water of the labyrinth, and set the otoliths and Corti's fibres in motion; I can also visualize the waves of ether

as they cross the eye and hit the retina. Nay, more, I am able to follow up to the central organ the motion thus imparted at the periphery, and to see in idea the very molecules of the brain thrown into tremors. My insight is not baffled by these physical processes. What baffles me, what I find unimaginable, transcending every faculty I possess—transcending, I humbly submit, every faculty *you* possess—is the notion that out of those physical tremors you can extract things so utterly incongruous with them as sensation, thought, and emotion. You may say, or think, that this issue of consciousness from the clash of atoms is not more incongruous than the flash of light from the union of oxygen and hydrogen. But I beg to say that it is. For such incongruity as the flash possesses is that which I now force upon your attention. The flash is an affair of consciousness, the objective counterpart of which is a vibration. It is a flash only by our interpretation. *You* are the cause of the apparent incongruity; and *you* are the thing that puzzles me. I need not remind you that the great Leibnitz felt the difficulty which I feel, and that to get rid of this monstrous deduction of life from death he displaced your atoms by his monads, and which were more or less perfect mirrors of the universe, and out of the summation and integration of which he supposed all the phenomena of life—sentient, intellectual, and emotional—to arise.

"Your difficulty, then, as I see you are ready to admit, is quite as great as mine. You cannot satisfy the human understanding in its demand for logical continuity between molecular processes and the phenomena of consciousness. This is a rock on which materialism must inevitably split whenever it pretends to be a complete philosophy of life. What is the moral, my Lucretian? You and I are not likely to indulge in ill-temper in the discussion of these great topics, where we see so much room for honest differences of opinion. But there are people of less wit, or more bigotry (I say it with humility), on both sides, who are ever ready to mingle anger and vituperation with such discussions. There are, for example, writers of note and influence at the present day who are not ashamed to assume the 'deep personal sin' of a great logician to be the cause of his unbelief in a theologic dogma. And there are others who hold that we, who cherish our noble Bible, wrought as it has been into the constitution of our forefathers, and by inheritance into us, must necessarily be hypocritical and insincere. Let us disavow and discountenance such people, cherishing the unswerving faith that what is good and true in both our arguments will be preserved for the benefit of humanity, while all that is bad or false will disappear."

It is worth remarking that in one respect the bishop was a product of his age. Long previous to his day the nature of the soul had been so favorite and general a topic of discussion that, when the students of the University of Paris wished to know the leanings of a new professor, they at once requested him to lecture upon the soul. About

the time of Bishop Butler the question was not only agitated but extended. It was seen by the clear-witted men who entered this arena that many of their best arguments applied equally to brutes and men. The bishop's arguments were of this character. He saw it, admitted it, accepted the consequences, and boldly embraced the whole animal world in his scheme of immortality.

Bishop Butler accepted with unwavering trust the chronology of the Old Testament, describing it as "confirmed by the natural and civil history of the world, collected from common historians, from the state of the earth, and from the late inventions of arts and sciences." These words mark progress; they must seem somewhat hoary to the Bishop's successors of to-day.[1] It is hardly necessary to inform you that, since his time, the domain of the naturalist has been immensely extended—the whole science of geology, with its astounding revelations regarding the life of the ancient earth, having been created. The rigidity of old conceptions has been relaxed, the public mind being rendered gradually tolerant of the idea that not for six thousand, nor for sixty thousand, nor for six thousand thousand, but for æons embracing untold millions of years, this earth has been the theatre of life and death. The riddle of the rocks has been read by the geologist and paleontologist, from sub-Cambrian depths to the deposits thickening over the sea-bottoms of to-day. And upon the leaves of that stone-book are, as you know, stamped the characters, plainer and surer than those formed by the ink of history, which carry the mind back into abysses of past time, compared with which the periods which satisfied Bishop Butler cease to have a visual angle. Everybody now knows this; all men admit it; still, when they were first broached, these verities of science found loud-tongued denunciators, who proclaimed not only their baselessness considered scientifically, but their immorality considered as questions of ethics and religion: the Book of Genesis had stated the question in a different fashion, and science must necessarily go to pieces when it clashed with this authority. And as the seed of the thistle produces a thistle, and nothing else, so these objectors scatter their germs abroad, and reproduce their kind, ready to play again the part of their intellectual progenitors, to show the same virulence, the same ignorance, to achieve for a time the same success, and finally to suffer the same inexorable defeat. Sure the time must come at last when human nature in its entirety, whose legitimate demands it is admitted science alone cannot satisfy, will find interpreters and expositors of a different stamp from those rash and ill-informed persons who have been hitherto so ready to hurl themselves against every new scientific revelation, lest it should endanger what they are pleased to consider theirs.

[1] Only to some; for there are dignitaries who even now speak of the earth's rocky crust as so much building-material prepared for man at the Creation. Surely it is time that this loose language should cease.

The lode of discovery once struck, those petrified forms in which life was at one time active increased to multitudes and demanded classification. The general fact soon became evident that none but the simplest forms of life lie lowest down—that as we climb higher and higher among the superimposed strata more perfect forms appear. The change, however, from form to form was not continuous, but by steps, some small, some great. "A section," says Mr. Huxley, "a hundred feet thick will exhibit at different heights a dozen species of ammonite, none of which passes beyond its particular zone of limestone, or clay, into the zone below it, or into that above it." In the presence of such facts it was not possible to avoid the question, Have these forms, showing, though in broken stages and with many irregularities, this unmistakable general advance, been subjected to no continuous law of growth or variation? Had our education been purely scientific, or had it been sufficiently detached from influences which, however ennobling in another domain, have always proved hindrances and delusions when introduced as factors into the domain of physics, the scientific mind never could have swerved from the search for a law of growth, or allowed itself to accept the anthropomorphism which regarded each successive stratum as a kind of mechanic's bench for the manufacture of new species out of all relation to the old.

Biased, however, by their previous education, the great majority of naturalists invoked a special creative act to account for the appearance of each new group of organisms. Doubtless there were numbers who were clear-headed enough to see that this was no explanation at all; that, in point of fact, it was an attempt, by the introduction of a greater difficulty, to account for a less. But, having nothing to offer in the way of explanation, they for the most part held their peace. Still the thoughts of reflecting men naturally and necessarily simmered round the question. De Maillet, a contemporary of Newton, has been brought into notice by Prof. Huxley as one who "had a notion of the modifiability of living forms." In my frequent conversations with him, the late Sir Benjamin Brodie, a man of highly-philosophic mind, often drew my attention to the fact that, as early as 1794, Charles Darwin's grandfather was the pioneer of Charles Darwin. In 1801, and in subsequent years, the celebrated Lamarck, who produced so profound an impression on the public mind through the vigorous exposition of his views by the author of "Vestiges of Creation," endeavored to show the development of species out of changes of habit and external condition. In 1813, Dr. Wells, the founder of our present theory of dew, read before the Royal Society a paper in which, to use the words of Mr. Darwin, "he distinctly recognizes the principle of natural selection; and this is the first recognition that has been indicated." The thoroughness and skill with which Wells pursued his work, and the obvious independence of his character, rendered him long ago a favorite with me; and it gave me the liveliest pleasure to

alight upon this additional testimony to his penetration. Prof. Grant, Mr. Patrick Matthew, Von Buch, the author of the "Vestiges," D'Halloy, and others,[1] by the enunciation of views more or less clear and correct, showed that the question had been fermenting long prior to the year 1858, when Mr. Darwin and Mr. Wallace simultaneously, but independently, placed their closely concurrent views upon the subject before the Linnean Society.

These papers were followed in 1859 by the publication of the first edition of "The Origin of Species." All great things come slowly to the birth. Copernicus, as I informed you, pondered his great work for thirty-three years. Newton for nearly twenty years kept the idea of Gravitation before his mind; for twenty years also he dwelt upon his discovery of Fluxions, and doubtless would have continued to make it the object of his private thought had he not found that Liebnitz was upon his track. Darwin for two-and-twenty years pondered the problem of the origin of species, and doubtless he would have continued to do so had he not found Wallace upon his track.[2] A concentrated but full and powerful epitome of his labors was the consequence. The book was by no means an easy one; and probably not one in every score of those who then attacked it had read its pages through, or was competent to grasp their significance if they had. I do not say this merely to discredit them, for there were in those days some really eminent scientific men, entirely raised above the heat of popular prejudice, willing to accept any conclusion that science had to offer, provided it was duly backed by fact and argument, and who entirely mistook Mr. Darwin's views. In fact, the work needed an expounder, and it found one in Mr. Huxley. I know nothing more admirable in the way of scientific exposition than those early articles of his on the origin of species. He swept the curve of discussion through the really significant points of the subject, enriched his exposition with profound original remarks and reflections, often summing up in a single pithy sentence an argument which a less compact mind would have spread over pages. But there is one impression made by the book itself which no exposition of it, however luminous, can convey, and that is the impression of the vast amount of labor, both of observation and of thought, implied in its production. Let us glance at its principles.

It is conceded on all hands that what are called varieties are continually produced. The rule is probably without exception. No chick and no child is in all respects and particulars the counterpart of its brother or sister; and in such differences we have "variety" incipient. No naturalist could tell how far this variation could be carried; but

[1] In 1855, Mr. Herbert Spencer ("Principles of Psychology," second edition, vol. i., p. 465) expressed "the belief that life under all its forms has arisen by an unbroken evolution, and through the instrumentality of what are called natural causes."

[2] The behavior of Mr. Wallace in relation to this subject has been dignified in the highest degree.

the great mass of them held that never by any amount of internal or external change, nor by the mixture of both, could the offspring of the same progenitor so far deviate from each other as to constitute different species. The function of the experimental philosopher is to combine the conditions of Nature and to produce her results; and this was the method of Darwin.[1] He made himself acquainted with what could, without any manner of doubt, be done in the way of producing variation. He associated himself with pigeon-fanciers—bought, begged, kept, and observed every breed that he could obtain. Though derived from a common stock, the diversities of these pigeons were such that "a score of them might be chosen which, if shown to an ornithologist, and he were told that they were wild birds, would certainly be ranked by him as well-defined species." The simple principle which guides the pigeon-fancier, as it does the cattle-breeder, is the selection of some variety that strikes his fancy, and the propagation of this variety by inheritance. With his eye still upon the particular appearance which he wishes to exaggerate, he selects it as it reappears in successive broods, and thus adds increment to increment until an astonishing amount of divergence from the parent type is effected. Man in this case does not produce the *elements* of the variation. He simply observes them, and, by selection, adds them together until the required result has been obtained. "No man," says Mr. Darwin, "would ever try to make a fantail till he saw a pigeon with a tail developed in some slight degree in an unusual manner, or a pouter until he saw a pigeon with a crop of unusual size." Thus Nature gives the hint, man acts upon it, and, by the law of inheritance, exaggerates the deviation.

Having thus satisfied himself by indubitable facts that the organization of an animal or of a plant (for precisely the same treatment applies to plants) is to some extent plastic, he passes from variation under domestication to variation under Nature. Hitherto we have dealt with the adding together of small changes by the conscious selection of man. Can Nature thus select? Mr. Darwin's answer is, "Assuredly she can." The number of living things produced is far in excess of the number that can be supported; hence at some period or other of their lives there must be a struggle for existence; and what is the infallible result? If one organism were a perfect copy of the other in regard to strength, skill, and agility, external conditions would decide. But this is not the case. Here we have the fact of variety offering itself to Nature, as in the former instance it offered itself to man; and those varieties which are least competent to cope with surrounding conditions will infallibly give way to those that are competent. To use a familiar proverb, the weakest comes to the wall. But the triumphant fraction again breeds to over-production, trans-

[1] The first step only toward experimental demonstration has been taken. Experiments now begun might, a couple of centuries hence, furnish data of incalculable value, which ought to be supplied to the science of the future.

mitting the qualities which secured its maintenance, but transmitting them in different degrees. The struggle for food again supervenes, and those to whom the favorable quality has been transmitted in excess will assuredly triumph. It is easy to see that we have here the addition of increments favorable to the individual still more rigorously carried out than in the case of domestication; for not only are unfavorable specimens not selected by Nature, but they are destroyed. This is what Mr. Darwin calls "Natural Selection," which "acts by the preservation and accumulation of small inherited modifications, each profitable to the preserved being." With this idea he interpenetrates and leavens the vast store of facts that he and others have collected. We cannot, without shutting our eyes through fear or prejudice, fail to see that Darwin is here dealing, not with imaginary, but with true causes; nor can we fail to discern what vast modifications may be produced by natural selection in periods sufficiently long. Each individual increment may resemble what mathematicians call a "differential" (a quantity indefinitely small); but definite and great changes may obviously be produced by the integration of these infinitesimal quantities through practically infinite time.

If Darwin, like Bruno, rejects the notion of creative power acting after human fashion, it certainly is not because he is unacquainted with the numberless exquisite adaptations on which this notion of a supernatural artificer has been founded. His book is a repository of the most startling facts of this description. Take the marvelous observation which he cites from Dr. Crüger, where a bucket with an aperture, serving as a spout, is formed in an orchid. Bees visit the flower: in eager search of material for their combs they push each other into the bucket, the drenched ones escaping from their involuntary bath by the spout. Here they rub their backs against the viscid stigma of the flower and obtain glue; then against the pollen-masses, which are thus stuck to the back of the bee and carried away. "When the bee, thus provided, flies to another flower, or to the same flower a second time, and is pushed by his comrades into the bucket, and then crawls out by the passage, the pollen-mass upon its back necessarily comes first into contact with the viscid stigma," which takes up the pollen; and this is how that orchid is fertilized. Or take this other case of the *Catasetum*. "Bees visit these flowers in order to gnaw the labellum; on doing this they inevitably touch a long, tapering, sensitive projection. This, when touched, transmits a sensation or vibration to a certain membrane, which is instantly ruptured, setting free a spring, by which the pollen-mass is shot forth like an arrow in the right direction, and adheres by its viscid extremity to the back of the bee." In this way the fertilizing pollen is spread abroad.

It is the mind thus stored with the choicest materials of the teleologist that rejects teleology, seeking to refer these wonders to natural causes. They illustrate, according to him, the method of Nature, not

the "technic" of a man-like Artificer. The beauty of flowers is due to natural selection. Those that distinguish themselves by vividly contrasting colors from the surrounding green leaves are most readily seen, most frequently visited by insects, most often fertilized, and hence most favored by natural selection. Colored berries also readily attract the attention of birds and beasts, which feed upon them, and spread their manured seeds abroad, thus giving trees and shrubs possessing such berries a greater chance in the struggle for existence.

With profound analytic and synthetic skill, Mr. Darwin investigates the cell-making instinct of the hive-bee. His method of dealing with it is representative. He falls back from the more perfectly to the less perfectly developed instinct—from the hive-bee to the humble-bee, which uses its own cocoon as a comb, and to classes of bees of intermediate skill, endeavoring to show how the passage might be gradually made from the lowest to the highest. The saving of wax is the most important point in the economy of bees. Twelve to fifteen pounds of dry sugar are said to be needed for the secretion of a single pound of wax. The quantities of nectar necessary for the wax must therefore be vast; and every improvement of constructive instinct which results in the saving of wax is a direct profit to the insect's life. The time that would otherwise be devoted to the making of wax is now devoted to the gathering and storing of honey for winter food. He passes from the humble-bee, with its rude cells, through the Melipona with its more artistic cells, to the hive-bee with its astonishing architecture. The bees place themselves at equal distances apart upon the wax, sweep and excavate equal spheres round the selected points. The spheres intersect, and the planes of intersection are built up with thin laminæ. Hexagonal cells are thus formed. This mode of treating such questions is, as I have said, representative. He habitually retires from the more perfect and complex, to the less perfect and simple, carries you with him through stages of perfecting, adds increment to increment of infinitesimal change, and in this way gradually breaks down your reluctance to admit that the exquisite climax of the whole could be a result of natural selection.

Mr. Darwin shirks no difficulty; and, saturated as the subject was with his own thought, he must have known, better than his critics, the weakness as well as the strength of his theory. This, of course, would be of little avail were his object a temporary dialectic victory instead of the establishment of a truth which he means to be everlasting. But he takes no pains to disguise the weakness he has discerned; nay, he takes every pains to bring it into the strongest light. His vast resources enable him to cope with objections started by himself and others, so as to leave the final impression upon the reader's mind that if they be not completely answered they certainly are not fatal. Their negative force being thus destroyed, you are free to be influenced by the vast positive mass of evidence he is able to bring

before you. This largeness of knowledge and readiness of resource render Mr. Darwin the most terrible of antagonists. Accomplished naturalists have leveled heavy and sustained criticisms against him—not always with the view of fairly weighing his theory, but with the express intention of exposing its weak points only. This does not irritate him. He treats every objection with a soberness and thoroughness which even Bishop Butler might be proud to imitate, surrounding each fact with its appropriate detail, placing it in its proper relations, and usually giving it a significance which, as long as it was kept isolated, failed to appear. This is done without a trace of ill-temper. He moves over the subject with the passionless strength of a glacier; and the grinding of the rocks is not always without a counterpart in the logical pulverization of the objector. But, though, in handling this mighty theme, all passion has been stilled, there is an emotion of the intellect incident to the discernment of new truth which often colors and warms the pages of Mr. Darwin. His success has been great; and this implies not only the solidity of his work, but the preparedness of the public mind for such a revelation. On this head a remark of Agassiz impressed me more than any thing else. Sprung from a race of theologians, this celebrated man combated to the last the theory of natural selection. One of the many times I had the pleasure of meeting him in the United States was at Mr. Winthrop's beautiful residence at Brookline, near Boston. Rising from luncheon, we all halted, as if by a common impulse, in front of a window, and continued there a discussion which had been started at table. The maple was in its autumn glory; and the exquisite beauty of the scene outside seemed, in my case, to interpenetrate without disturbance the intellectual action. Earnestly, almost sadly, Agassiz turned and said to the gentlemen standing round: "I confess that I was not prepared to see this theory received as it has been by the best intellects of our time. Its success is greater than I could have thought possible."

In our day great generalizations have been reached. The theory of the origin of species is but one of them. Another, of still wider grasp and more radical significance, is the doctrine of the Conservation of Energy, the ultimate philosophical issues of which are as yet but dimly seen—that doctrine which "binds Nature fast in fate" to an extent not hitherto recognized, exacting from every antecedent its equivalent consequent, from every consequent its equivalent antecedent, and bringing vital as well as physical phenomena under the dominion of that law of causal connection which, as far as the human understanding has yet pierced, asserts itself everywhere in Nature. Long in advance of all definite experiment upon the subject, the constancy and indestructibility of matter had been affirmed; and all subsequent experience justified the affirmation. Later researches extended the attribute of indestructibility to force. This idea, applied in the first instance to inorganic, rapidly embraced organic Nature. The

vegetable world, though drawing almost all its nutriment from invisible sources, was proved incompetent to generate anew either matter or force. Its matter is for the most part transmuted air; its force transformed solar force. The animal world was proved to be equally uncreative, all its motive energies being referred to the combustion of its food. The activity of each animal as a whole was proved to be the transferred activities of its molecules. The muscles were shown to be stores of mechanical force, potential until unlocked by the nerves, and then resulting in muscular contractions. The speed at which messages fly to and fro along the nerves was determined, and found to be, not as had been previously supposed, equal to that of light or electricity, but less than the speed of a flying eagle.

This was the work of the physicist: then came the conquests of the comparative anatomist and physiologist, revealing the structure of every animal, and the function of every organ in the whole biological series, from the lowest zoophyte up to man. The nervous system had been made the object of profound and continued study, the wonderful and, at bottom, entirely mysterious controlling power which it exercises over the whole organism, physical and mental, being recognized more and more. Thought could not be kept back from a subject so profoundly suggestive. Besides the physical life dealt with by Mr. Darwin, there is a psychical life presenting similar gradations, and asking equally for a solution. How are the different grades and orders of mind to be accounted for? What is the principle of growth of that mysterious power which on our planet culminates in Reason? These are questions which, though not thrusting themselves so forcibly upon the attention of the general public, had not only occupied many reflecting minds, but had been formally broached by one of them before the "Origin of Species" appeared.

With the mass of materials furnished by the physicist and physiologist in his hands, Mr. Herbert Spencer, twenty years ago, sought to graft upon this basis a system of psychology; and two years ago a second and greatly-amplified edition of his work appeared. Those who have occupied themselves with the beautiful experiments of Plateau, will remember that, when two spherules of olive-oil, suspended in a mixture of alcohol-and-water of the same density as the oil, are brought together, they do not immediately unite. Something like a pellicle appears to be formed around the drops, the rupture of which is immediately followed by the coalescence of the globules into one. There are organisms whose vital actions are almost as purely physical as that of these drops of oil. They come into contact and fuse themselves thus together. From such organisms to others a shade higher, and from these to others a shade higher still, and on through an ever-ascending series, Mr. Spencer conducts his argument. There are two obvious factors to be here taken into account—the creature and the medium in which it lives, or, as it is often expressed, the organism and

its environment. Mr. Spencer's fundamental principle is, that between these two factors there is incessant interaction. The organism is played upon by the environment, and is modified to meet the requirements of the environment. Life he defines to be "a continuous adjustment of internal relations to external relations."

In the lowest organisms we have a kind of tactual sense diffused over the entire body; then, through impressions from without and their corresponding adjustments, special portions of the surface become more responsive to stimuli than others. The senses are nascent, the basis of all of them being that simple tactual sense which the sage Democritus recognized 2,300 years ago as their common progenitor. The action of light, in the first instance, appears to be a mere disturbance of the chemical processes in the animal organism, similar to that which occurs in the leaves of plants. By degrees the action becomes localized in a few pigment-cells, more sensitive to light than the surrounding tissue. The eye is here incipient. At first it is merely capable of revealing differences of light and shade produced by bodies close at hand. Followed as the interception of the light is in almost all cases by the contact of the closely-adjacent, opaque body, sight in this condition becomes a kind of "anticipatory touch." The adjustment continues; a slight bulging out of the epidermis over the pigment-granules supervenes. A lens is incipient, and, through the operation of infinite adjustments, at length reaches the perfection that it displays in the hawk and the eagle. So of the other senses; they are special differentiations of a tissue which was originally vaguely sensitive all over.

With the development of the senses the adjustments between the organism and its environment gradually extend in *space*, a multiplication of experiences and a corresponding modification of conduct being the result. The adjustments also extend in *time*, covering continually greater intervals. Along with this extension in space and time, the adjustments also increase in specialty and complexity, passing through the various grades of brute-life and prolonging themselves into the domain of reason. Very striking are Mr. Spencer's remarks regarding the influence of the sense of touch upon the development of intelligence. This is, so to say, the mother-tongue of all the senses, into which they must be translated to be of service to the organism. Hence its importance. The parrot is the most intelligent of birds, and its tactual power is also greatest. From this sense it gets knowledge unattainable by birds which cannot employ their feet as hands. The elephant is the most sagacious of quadrupeds—its tactual range and skill, and the consequent multiplication of experiences, which it owes to its wonderfully adaptable trunk, being the basis of its sagacity. Feline animals, for a similar cause, are more sagacious than hoofed animals—atonement being to some extent made, in the case of the horse, by the possession of sensible prehensile lips. In the *Primates*

the evolution of intellect and the evolution of tactual appendages go hand in hand. In the most intelligent anthropoid apes we find the tactual range and delicacy greatly augmented, new avenues of knowledge being thus opened to the animal. Man crowns the edifice here, not only in virtue of his own manipulatory power, but through the enormous extension of his range of experience, by the invention of instruments of precision, which serve as supplemental senses and supplemental limbs. The reciprocal action of these is finely described and illustrated. That chastened intellectual emotion to which I have referred in connection with Mr. Darwin is, I should say, not absent in Mr. Spencer. His illustrations possess at times exceeding vividness and force, and from his style on such occasions it is to be inferred that the ganglia of this apostle of the understanding are sometimes the seat of a nascent poetic thrill.

It is a fact of supreme importance that actions, the performance of which at first requires even painful effort and deliberation, may, by habit, be rendered automatic. Witness the slow learning of its letters by a child, and the subsequent facility of reading in a man, when each group of letters which forms a word is instantly and without effort fused to a single perception. Instance the billiard-player, whose muscles of hand and eye, when he reaches the perfection of his art, are unconsciously coördinated. Instance the musician, who, by practice, is enabled to fuse a multitude of arrangements, auditory, tactual, and muscular, into a process of automatic manipulation. Combining such facts with the doctrine of hereditary transmission, we reach a theory of instinct. A chick, after coming out of the egg, balances itself correctly, runs about, picks up food, thus showing that it possesses a power of directing its movements to definite ends. How did the chick learn this very complex coördination of eye, muscles, and beak? It has not been individually taught; its personal experience is *nil;* but it has the benefit of ancestral experience. In its inherited organization are registered all the powers which it displays at birth. So also as regards the instinct of the hive-bee already referred to. The distance at which the insects stand apart when they sweep their hemispheres and build their cells is "organically remembered." Man also carries with him the physical texture of his ancestry, as well as the inherited intellect bound up with it. The defects of intelligence during infancy and youth are probably less due to a lack of individual experience than to the fact that in early life the cerebral organization is still incomplete. The period necessary for completion varies with the race, and with the individual. As a round shot outstrips a rifled one on quitting the muzzle of the gun, so the lower race in childhood may outstrip the higher. But the higher eventually overtakes the lower, and surpasses it in range. As regards individuals, we do not always find the precocity of youth prolonged to mental power in maturity; while the dullness of boyhood is sometimes strikingly contrasted with

the intellectual energy of after-years. Newton, when a boy, was weakly, and he showed no particular aptitude at school; but in his eighteenth year he went to Cambridge, and soon afterward astonished his teachers by his power of dealing with geometrical problems. During his quiet youth his brain was slowly preparing itself to be the organ of those energies which he subsequently displayed.

By myriad blows (to use a Lucretian phrase) the image and superscription of the external world are stamped as states of consciousness upon the organism, the depth of the impression depending upon the number of the blows. When two or more phenomena occur in the environment invariably together, they are stamped to the same depth or to the same relief, and indissolubly connected. And here we come to the threshold of a great question. Seeing that he could in no way rid himself of the consciousness of Space and Time, Kant assumed them to be necessary "forms of thought," the moulds and shapes into which our intuitions are thrown, belonging to ourselves solely and without objective existence. With unexpected power and success Mr. Spencer brings the hereditary-experience theory, as he holds it, to bear upon this question. "If there exist certain external relations which are experienced by all organisms at all instants of their waking lives—relations which are absolutely constant and universal—there will be established answering internal relations that are absolutely constant and universal. Such relations we have in those of Space and Time. As the substratum of all other relations of the Non-Ego, they must be responded to by conceptions that are the substrata of all other relations in the Ego. Being the constant and infinitely repeated elements of thought, they must become the automatic elements of thought—the elements of thought which it is impossible to get rid of—the 'forms of intuition.'"

Throughout this application and extension of the "Law of Inseparable Association," Mr. Spencer stands on totally different ground from Mr. John Stuart Mill, invoking the registered experiences of the race instead of the experiences of the individual. His overthrow of Mr. Mill's restriction of experience is, I think, complete. That restriction ignores the power of organizing experience furnished at the outset to each individual; it ignores the different degrees of this power possessed by different races and by different individuals of the same race. Were there not in the human brain a potency antecedent to all experience, a dog or cat ought to be as capable of education as a man. These predetermined internal relations are independent of the experiences of the individual. The human brain is the "organized register of infinitely numerous experiences received during the evolution of life, or rather during the evolution of that series of organisms through which the human organism has been reached. The effects of the most uniform and frequent of these experiences have been successively bequeathed, principal and interest, and have slowly mounted to that

high intelligence which lies latent in the brain of the infant. Thus it happens that the European inhabits from twenty to thirty cubic inches more of brain than the Papuan. Thus it happens that faculties, as of music, which scarcely exist in some inferior races, become congenital in superior ones. Thus it happens that out of savages unable to count up to the number of their fingers, and speaking a language containing only nouns and verbs, arise at length our Newtons and Shakespeares."

At the outset of this address it was stated that physical theories which lie beyond experience are divided by a process of abstraction from experience. It is instructive to note from this point of view the successive introduction of new conceptions. The idea of the attraction of gravitation was preceded by the observation of the attraction of iron by a magnet, and of light bodies by rubbed amber. The polarity of magnetism and electricity appealed to the senses; and thus became the substratum of the conception that atoms and molecules are endowed with definite, attractive, and repellent poles, by the play of which definite forms of crystalline architecture are produced. Thus molecular force becomes *structural*. It required no great boldness of thought to extend its play into organic Nature, and to recognize in molecular force the agency by which both plants and animals are built up. In this way, out of experience arise conceptions which are wholly ultra-experiential.

The *origination* of life is a point lightly touched upon, if at all, by Mr. Darwin and Mr. Spencer. Diminishing gradually the number of progenitors, Mr. Darwin comes at length to one "primordial form;" but he does not say, as far as I remember, how he supposes this form to have been introduced. He quotes with satisfaction the words of a celebrated author and divine who had "gradually learned to see that it is just as noble a conception of the Deity to believe He created a few original forms, capable of self-development into other and needful forms, as to believe that He required a fresh act of creation to supply the voids caused by the action of his laws." What Mr. Darwin thinks of this view of the introduction of life I do not know. Whether he does or does not introduce his "primordial form" by a creative act, I do not know. But the question will inevitably be asked, "How came the form there?" With regard to the diminution of the number of created forms, one does not see that much advantage is gained by it. The anthropomorphism, which it seemed the object of Mr. Darwin to set aside, is as firmly associated with the creation of a few forms as with the creation of a multitude. We need clearness and thoroughness here. Two courses, and two only, are possible. Either let us open our doors freely to the conception of creative acts, or, abandoning them, let us radically change our notions of matter. If we look at matter as pictured by Democritus, and as defined for generations in our scientific text-books, the absolute impossibility of any form of life coming out of it would be sufficient to render any other

hypothesis preferable; but the definitions of matter given in our text-books were intended to cover its purely physical and mechanical properties. And, taught as we have been to regard these definitions as complete, we naturally and rightly reject the monstrous notion that out of *such* matter any form of life could possibly arise. But are the definitions complete? Every thing depends on the answer to be given to this question. Trace the line of life backward, and see it approaching more and more to what we call the purely physical condition. We reach at length those organisms which I have compared to drops of oil suspended in a mixture of alcohol-and-water. We reach the *protogenes* of Haeckel, in which we have "a type distinguishable from a fragment of albumen only by its finely-granular character." Can we pause here? We break a magnet, and find two poles in each of its fragments. We continue the process of breaking, but, however small the parts, each carries with it, though enfeebled, the polarity of the whole. And, when we can break no longer, we prolong the intellectual vision to the polar molecules. Are we not urged to do *something* similar in the case of life? Is there not a temptation to close to some extent with Lucretius, when he affirms that "Nature is seen to do all things spontaneously of herself without the meddling of the gods?" or with Bruno, when he declares that Matter is not "that mere empty *capacity* which philosophers have pictured her to be, but the universal mother who brings forth all things as the fruit of her own womb?" The questions here raised are inevitable. They are approaching us with accelerated speed, and it is not a matter of indifference whether they are introduced with reverence or irreverence. Abandoning all disguise, the confession that I feel bound to make before you is that I prolong the vision backward across the boundary of the experimental evidence, and discern in that matter, which we in our ignorance, and notwithstanding our professed reverence for its Creator, have hitherto covered with opprobrium, the promise and potency of every form and quality of life.

The "materialism" here enunciated may be different from what you suppose, and I therefore crave your gracious patience to the end. "The question of an external world," says Mr. J. S. Mill, "is the great battle-ground of metaphysics."[1] Mr. Mill himself reduces external phenomena to "possibilities of sensation." Kant, as we have seen, made time and space "forms" of our own intuitions. Fichte, having first by the inexorable logic of his understanding proved himself to be a mere link in that chain of eternal causation which holds so rigidly in Nature, violently broke the chain by making Nature, and all that it inherits, an apparition of his own mind.[2] And it is by no means easy to combat such notions. For, when I say I see you, and that I have not the least doubt about it, the reply is, that what I am really conscious of is an affection of my own retina. And if I urge

[1] "Examination of Hamilton," p. 154. [2] "Bestimmung des Menschen."

that I can check my sight of you by touching you, the retort would be that I am equally transgressing the limits of fact; for what I am really conscious of is, not that you are there, but that the nerves of my hand have undergone a change. All we hear, and see, and touch, and taste, and smell, are, it would be urged, mere variations of our own condition, beyond which, even to the extent of a hair's breadth, we cannot go. That any thing answering to our impressions exists outside of ourselves is not a *fact*, but an *inference*, to which all validity would be denied by an idealist like Berkeley, or by a skeptic like Hume. Mr. Spencer takes another line. With him, as with the uneducated man, there is no doubt or question as to the existence of an external world. But he differs from the uneducated, who think that the world really *is* what consciousness represents it to be. Our states of consciousness are mere *symbols* of an outside entity which produces them and determines the order of their succession, but the real nature of which we can never know.[1] In fact, the whole process of evolution is the manifestation of a Power absolutely inscrutable to the intellect of man. As little in our day as in the days of Job, can man, by searching, find this Power out. Considered fundamentally, it is by the operation of an insoluble mystery that life is evolved, species differentiated, and mind unfolded from their prepotent elements in the immeasurable past. There is, you will observe, no very rank materialism here.

The strength of the doctrine of evolution consists, not in an experimental demonstration (for the subject is hardly accessible to this mode of proof), but in its general harmony with the method of Nature as hitherto known. From contrast, moreover, it derives enormous relative strength. On the one side we have a theory (if it could with any propriety be so called) derived, as were the theories referred to at the beginning of this address, not from the study of Nature, but from the observation of men—a theory which converts the Power whose garment is seen in the visible universe into an Artificer, fashioned after the human model, and acting by broken efforts as man is seen to act. On the other side we have the conception that all we see around us,

[1] In a paper, at once popular and profound, entitled "Recent Progress in the Theory of Vision," contained in the volume of lectures by Helmholtz published by Longmans, this symbolism of our states of consciousness is also dwelt upon. The impressions of sense are the mere *signs* of external things. In this paper Helmholtz contends strongly against the view that the consciousness of space is inborn; and he evidently doubts the power of the chick to pick up grains of corn without some preliminary lessons. On this point, he says, further experiments are needed. Such experiments have been since made by Mr. Spalding, aided, I believe, in some of his observations by the accomplished and deeply-lamented Lady Amberley; and they seem to prove conclusively that the chick does not need a single moment's tuition to teach it to stand, run, govern the muscles of its eyes, and peck. Helmholtz, however, is contending against the notion of prëstablished harmony: and I am not aware of his views as to the organization of experiences of race or breed.

and all we feel within us—the phenomena of physical Nature as well as those of the human mind—have their unsearchable roots in a cosmical life, if I dare apply the term, an infinitesimal span of which only is offered to the investigation of man. And even this span is only knowable in part. We can trace the development of a nervous system, and correlate with it the parallel phenomena of sensation and thought. We see with undoubting certainty that they go hand in hand. But we try to soar in a vacuum the moment we seek to comprehend the connection between them. An Archimedean fulcrum is here required which the human mind cannot command; and the effort to solve the problem, to borrow an illustration from an illustrious friend of mine, is like the effort of a man trying to lift himself by his own waistband. All that has been here said is to be taken in connection with this fundamental truth. When "nascent senses" are spoken of, when "the differentiation of a tissue at first vaguely sensitive all over" is spoken of, and when these processes are associated with "the modification of an organism by its environment," the same parallelism, without contact, or even approach to contact, is implied. There is no fusion possible between the two classes of facts—no motor energy in the intellect of man to carry it without logical rupture from the one to the other.

Further, the doctrine of evolution derives man, in his totality, from the interaction of organism and environment through countless ages past. The human understanding, for example—the faculty which Mr. Spencer has turned so skillfully round upon its own antecedents—is itself a result of the play between organism and environment through cosmic ranges of time. Never surely did prescription plead so irresistible a claim. But then it comes to pass that, over and above his understanding, there are many other things appertaining to man whose prescriptive rights are quite as strong as that of the understanding itself. It is a result, for example, of the play of organism and environment that sugar is sweet and that aloes are bitter, that the smell of henbane differs from the perfume of a rose. Such facts of consciousness (for which, by-the-way, no adequate reason has ever yet been rendered) are quite as old as the understanding itself, and many other things can boast an equally ancient origin. Mr. Spencer at one place refers to that most powerful of passions—the amatory passion—as one which, when it first occurs, is antecedent to all relative experience whatever, and we may pass its claim as being at least as ancient and as valid as that of the understanding itself. Then there are such things woven into the texture of man as the feeling of awe, reverence, wonder—and not alone the sexual love just referred to, but the love of the beautiful, physical and moral, in Nature, poetry, and art. There is also that deep-set feeling which, since the earliest dawn of history, and probably for ages prior to all history, incorporated itself in the religions of the world. You who have escaped from these

religions in the high-and-dry light of the understanding may deride them; but in so doing you deride accidents of form merely, and fail to touch the immovable basis of the religious sentiment in the emotional nature of man. To yield this sentiment reasonable satisfaction is the problem of problems at the present hour. And grotesque in relation to scientific culture as many of the religions of the world have been and are—dangerous, nay, destructive, to the dearest privileges of freemen as some of them undoubtedly have been, and would, if they could, be again—it will be wise to recognize them as the forms of force, mischievous, if permitted to intrude on the region of *knowledge*, over which it holds no command, but capable of being guided by liberal thought to noble issues in the region of *emotion*, which is its proper sphere. It is vain to oppose this force with a view to its extirpation. What we should oppose, to the death if necessary, is every attempt to found upon this elemental bias of man's nature a system which should exercise despotic sway over his intellect. I do not fear any such consummation. Science has already, to some extent, leavened the world, and it will leaven it more and more. I should look upon the mild light of science breaking in upon the minds of the youth of Ireland, and strengthening gradually to the perfect day, as a surer check to any intellectual or spiritual tyranny which might threaten this island, than the laws of princes or the swords of emperors. Where is the cause of fear? We fought and won our battle even in the middle ages, why should we doubt the issue of a conflict now?

The impregnable position of science may be described in a few words. All religious theories, schemes, and systems, which embrace notions of cosmogony, or which otherwise reach into its domain, must, in so far as they do this, submit to the control of science, and relinquish all thought of controlling it. Acting otherwise proved disastrous in the past, and it is simply fatuous to-day. Every system which would escape the fate of an organism too rigid to adjust itself to its environment, must be plastic to the extent that the growth of knowledge demands. When this truth has been thoroughly taken in, rigidity will be relaxed, exclusiveness diminished, things now deemed essential will be dropped, and elements now rejected will be assimilated. The lifting of the life is the essential point, and as long as dogmatism, fanaticism, and intolerance, are kept out, various modes of leverage may be employed to raise life to a higher level. Science itself not unfrequently derives motive-power from an ultra-scientific source. Whewell speaks of enthusiasm of temper as a hindrance to science; but he means the enthusiasm of weak heads. There is a strong and resolute enthusiasm in which science finds an ally; and it is to the lowering of this fire rather than to a diminution of intellectual insight, that the lessening productiveness of men of science in their mature years is to be ascribed. Mr. Buckle sought to detach intellectual achievement from moral force. He gravely erred; for, without

moral force to whip it into action, the achievements of the intellect would be poor indeed.

It has been said that science divorces itself from literature. The statement, like so many others, arises from lack of knowledge. A glance at the less technical writings of its leaders—of its Helmholtz, its Huxley, and its Du Bois-Reymond—would show what breadth of literary culture they command. Where among modern writers can you find their superiors in clearness and vigor of literary style? Science desires no isolation, but freely combines with every effort toward the bettering of man's estate. Single-handed, and supported not by outward sympathy, but by inward force, it has built at least one great wing of the many-mansioned home which man in his totality demands. And if rough walls and protruding rafter-ends indicate that on one side the edifice is still incomplete, it is only by wise combination of the parts required with those already irrevocably built that we can hope for completeness. There is no necessary incongruity between what has been accomplished and what remains to be done. The moral glow of Socrates, which we all feel by ignition, has in it nothing incompatible with the physics of Anaxagoras which he so much scorned, but which he would hardly scorn to-day. And here I am reminded of one among us, hoary, but still strong, whose prophet-voice some thirty years ago, far more than any other of this age, unlocked whatever of life and nobleness lay latent in its most gifted minds—one fit to stand beside Socrates or the Maccabean Eleazar, and to dare and suffer all that they suffered and dared—fit, as he once said of Fichte, "to have been the teacher of the Stoa, and to have discoursed of beauty and virtue in the groves of Academe." With a capacity to grasp physical principles, which his friend Goethe did not possess, and which even total lack of exercise has not been able to reduce to atrophy, it is the world's loss that he, in the vigor of his years, did not open his mind and sympathies to science, and make its conclusions a portion of his message to mankind. Marvelously endowed as he was—equally equipped on the side of the heart and of the understanding—he might have done much toward teaching us how to reconcile the claims of both, and to enable them in coming times to dwell together in unity of spirit and in the bond of peace.

And now the end is come. With more time, or greater strength and knowledge, what has been here said might have been better said, while worthy matters here omitted might have received fit expression. But there would have been no material deviation from the views set forth. As regards myself, they are not the growth of a day; and as regards you, I thought you ought to know the environment which, with or without your consent, is rapidly surrounding you, and in relation to which some adjustment on your part may be necessary. A hint of Hamlet's, however, teaches us all how the troubles of common life may be ended; and it is perfectly possible for you and me to pur-

chase intellectual peace at the price of intellectual death. The world is not without refuges of this description; nor is it wanting in persons who seek their shelter and try to persuade others to do the same. I would exhort you to refuse such shelter, and to scorn such base repose —to accept, if the choice be forced upon you, commotion before stagnation, the leap of the torrent before the stillness of the swamp. In the one there is at all events life, and therefore hope; in the other, none. I have touched on debatable questions, and led you over dangerous ground—and this partly with the view of telling you, and through you the world, that as regards these questions science claims unrestricted right of search. It is not to the point to say that the views of Lucretius and Bruno, of Darwin and Spencer, may be wrong. Here I should agree with you, deeming it indeed certain that these views will undergo modification. But the point is, that, whether right or wrong, we claim the freedom to discuss them. The ground which they cover is scientific ground; and the right claimed is one made good through tribulation and anguish, inflicted and endured in darker times than ours, but resulting in the immortal victories which science has won for the human race. I would set forth equally the inexorable advance of man's understanding in the path of knowledge, and the unquenchable claims of his emotional nature which the understanding can never satisfy. The world embraces not only a Newton, but a Shakespeare—not only a Boyle, but a Raphael—not only a Kant, but a Beethoven—not only a Darwin, but a Carlyle. Not in each of these, but in all, is human nature whole. They are not opposed, but supplementary—not mutually exclusive, but reconcilable. And if, still unsatisfied, the human mind, with the yearning of a pilgrim for his distant home, will turn to the mystery from which it has emerged, seeking so to fashion it as to give unity to thought and faith, so long as this is done, not only without intolerance or bigotry of any kind, but with the enlightened recognition that ultimate fixity of conception is here unattainable, and that each succeeding age must be held free to fashion the mystery in accordance with its own needs—then, in opposition to all the restrictions of materialism, I would affirm this to be a field for the noblest exercise of what, in contrast with the *knowing* faculties, may be called the *creative* faculties of man. Here, however, I must quit a theme too great for me to handle, but which will be handled by the loftiest minds ages after you and I, like streaks of morning cloud, shall have melted into the infinite azure of the past.

THE AQUARIUM.

By WILLIAM E. SIMMONS, Jr.

IT is a subject for regret, as well from a national as a scientific point of view, that, while London, Paris, Berlin, Hamburg, Naples, Brighton, in fact nearly every European city of note, has its aquarium, or aquaria, New York, the metropolis of the New World, is as yet without one. True, the necessity has not been overlooked; but, beyond the agitation of the subject, no practical steps have, I believe, been taken in the matter. To the conductors of Appletons' Journal belongs the honor of having first directed public attention to the necessity for establishing an aquarium at Central Park, and their praiseworthy efforts to that end have received, besides the very general approval of the daily press, encomiums from Prof. Henry and other eminent scientific men. Indeed, in the latter part of 1873, they even opened the way for securing to the enterprise the valuable services of Mr. W. Saville Kent, late Curator of the Brighton Aquarium. Unfortunately, during the delay that has subsequently occurred in the development of the scheme, Mr. Kent has been induced to accept the curatorship of the Manchester (England) Aquarium.

But of what use, it may be asked, other than embellishment, is the aquarium? The scientific reader, knowing its value, will not require an answer; but, to the unscientific, it doubtless seems of small practical use to spend time and money in gathering together a few fish and plants, that their growth and movements may be observed. The answer is, first, its scientific value. Its influence would be to engender in the thousands who would daily visit it a taste for scientific knowledge and pursuits. In seeing the objects it contained, people would naturally find a desire to know something of them beyond what can be learned by cursory observation, and thus be led to scientific reading and scientific education. Second, it constitutes a science by itself, and therefore demands the same encouragement that is given to any other one science. It is not yet half a century since Madame Jeannette Power began the study of marine animals, by the aid of glass cases filled with water, in which she confined them; still almost our entire knowledge of aquatic zoology having been obtained through the aquarium rests upon it. A striking result, recently obtained, is at least a partial settlement of the vexed question whether fish hear; the observations of Mr. Henry Lee on that subject, in the Brighton Aquarium, having determined that some fish certainly do hear.

In addition to these very cogent reasons is the fact that the aquarium is a never-failing source of interest. The objects it presents are, many of them, entirely new to human sight, and not a few are wonderfully beautiful. So great is the attraction of the aquarium, that,

wherever established as a pecuniary investment, it has never failed to yield the most profitable results. Thus the aquarium at Hamburg has proved an immense pecuniary success; and that at Brighton, although beginning its existence so recently as August, 1872, has nevertheless already made a gratifying return to its proprietors.

FIG. 1.

MAIN TANK, BRIGHTON AQUARIUM (Half-Section).

The aquarium further serves to illustrate an important biological truth—one of the most subtile relations between the animal and vegetable kingdoms. That truth is, that the two kingdoms exert complementary influences upon the atmosphere we breathe. Plants inhale carbon and exhale oxygen; animals do the reverse. Strike out all the plants from existence, and we should, poisoned by our own breath, die in heaps, with other animals; while, if all the animals could, at one blow, be swept away from the earth into space, the plants would be destroyed by the want of carbon. And now the aquarium, which, properly speaking, is an artificial sea, or lake, possessing all the conditions necessary to the maintenance of aquatic life, both animal and vegetable, beautifully illustrates this truth. Who has not observed that fish, confined in water without plants, quickly die, unless the water be repeatedly changed? The fish die because, having breathed out all the oxygen of the water, as there is nothing in it to produce any more, they become poisoned with the suffocating carbon. But, when the plants also are put in, they take up the carbon from the fish and go on producing oxygen all the while, so there is no longer any necessity for changing the water. The fact that marine aquaria do not require the introduction of plants has been supposed by some observers to furnish a contradiction of the truth just stated. But the contradiction is apparent only, not real. Sea, or "salt" water, as it is usually called, contains a great quantity of little germs or "spores,"

which quickly develop microscopic vegetation or *confervæ* upon the sides of the aquarium, and upon the rocks within it. This vegetation, although unobtrusive, performs all the work done by the more conspicuous plants of the fresh-water aquarium. The credit of inventing the aquarium proper has generally been given to Madame Power, before alluded to, who, in the year 1832 and thereabouts, while studying the marine animals on the coast of Sicily, brought into use the "water-cage" to facilitate her investigations. But Mr. W. Alford Lloyd, the present Curator of the Crystal Palace Aquarium, London, who is one of the highest authorities on the subject, contradicts that view. In an article published in *Science Gossip*, several years ago, he says that the introduction into the "water-cage" of "plants *for the avowed purpose stated beforehand*, of preserving the purity of the sea-water, and of sustaining the animals in health, is due to Mrs. Thynne, who experimented in London, in 1846, on living madrepores." Madame Power, it appears, was in the habit of changing the water in her cages. It would seem, therefore, that while to Madame Power belongs the credit of furnishing the clew to the scientific value of the aquarium, to Mrs. Thynne belongs that of inventing the aquarium itself.

Some interesting facts, not wholly of a zoological nature, have been observed through the aquarium. Thus it was ascertained that objects through the medium of water appear shorter than they really are. At the distance of a few feet, a fish, or other object, appears about one-fifth shorter than it is. Mr. Lloyd, through *Science Gossip*, has made known some curious effects of electricity on fish. A friend of his had a large fresh-water garden-aquarium. One day, during a thunder-storm, a house, about 200 feet from the aquarium, was struck by lightning. At the moment of the flash, all the fish in the aquarium, forty-three in number, of various kinds, were suddenly suspended perpendicularly, heads downward, with their tails at the surface of the water, in which position they feebly and vainly endeavored to swim to the bottom of the tank. "The manner in which the eels were almost jerked out of their hiding-places, in the sand at the bottom of the tank, was very remarkable. In less than half an hour forty-one were dead, strongly curved, almost in the form of semicircles, and fast decomposing; but two gradually recovered, by being placed in running water. It is well known that when fish become sick and die, under ordinary circumstances, they turn belly upward, horizontally, instead of having nose downward, as in this case."

These facts sufficiently indicate the utility of the aquarium, and the necessity for having one at Central Park. As an indication of the interest commanded by the subject in England, it may be mentioned that Mr. Kent has begun a series of lectures at Manchester, to show ow it subserves the purposes of scientific instruction. The first lecture was delivered on the last Friday in June to a fairly numerous

audience, and another will follow on every Friday afternoon during the summer.

One of the largest and most successful aquaria anywhere is that at Brighton, England. It is a private enterprise, and of very recent origin. It was originated by Mr. Edward Birch, an English engineer of note, who organized a stock company with a capital of $400,000. The work of construction was begun in 1869, and the building was formally thrown open to the public in August, 1872. The building stands upon the sea-beach, in front of the Marine Parade, its roof being a little below the level of that promenade. It has a total length of 715 feet, with a width of 100 feet. The interior is divided into two corridors, on either side of which stand the tanks containing the fish. The dominant style of architecture is the Italian, and highly ornate. The roof of the corridors is arched and groined, "constructed of variegated bricks, and supported on columns of Bath stone, polished serpentine marble, and Aberdeen granite. The capital of each column is elaborately carved in some appropriate marine device, while the floor, in correspondence, is laid out in acrostic tiles." The tanks number forty-one. Their fronts are made of plate-glass, one inch thick, divided into sheets three feet wide and six feet high, supported by upright iron mullions. At the eastern end of the west or main corridor is a fernery, with rock-work and cascade. Many of the tanks are also supplied with ornamental rock-work. For the accommodation of visitors there are a restaurant, dining-hall, and reading-room, in the building. The smallest tank measures 11 feet long by 10 broad, and contains about 4,000 gallons of water, while the largest measures 130 feet long, 30 broad, and holds 110,000 gallons. The latter is large enough to accommodate a small whale. At present, however, it contains only a porpoise, a few dog-fish, a ray, and several turtle. Six tanks are devoted to fresh-water animals, the rest to marine. The water of the latter is pumped up from the sea by steam when needed, but is never changed in any of the tanks except when required by turbidity, or any accident, such as the cracking of a front. To secure abundant aëration each tank is supplied with several vulcanite tubes, entering at the top and descending to the bottom. An air-pump, situated at one end of the building, and worked by steam, forces a stream of air into the tank through each tube. The result is, a constant bubbling up of the water. This plan, however, does not seem to be as desirable or efficient as the circulatory system maintained at the Crystal Palace Aquarium. This consists in merely pumping the water by steam up to a higher level, and allowing it to return, by force of gravity, through the tanks to the reservoir beneath. In its course it takes up a greater amount of oxygen than can be otherwise imparted to it, and at the same time acquires great clearness and brilliancy.

The best kind of vessel for a small aquarium is an oblong tank made of slate, with a glass front. Glass may be used instead of slate,

but the latter is desirable, because it is important that the light received into the aquarium should be admitted from above, while the dark sides and back give a more natural appearance to the occupants. The framework, if of iron, should be plated to prevent its rusting, as that would injure the plants and animals. If the parts are cemented, Portland cement should be used, as it is freer from impurities than other cements; however, even it should be soaked in water for several days previous to using. In the form of an aquarium, superficial area

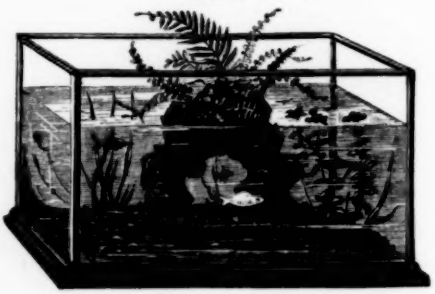
FIG. 2.

CHEAP AQUARIUM.

is more important than depth, because, the larger the surface in proportion to the depth, the greater will be the quantity of oxygen absorbed by the water. For household purposes, the cheapest and most convenient vessel for a small aquarium is the common bell-shaped glass used by confectioners to cover cakes. When this is used, green paper should be pasted upon the outside, except on the front, from the level of the water to the bottom. For marine aquaria the bottom should rise a short distance from the front, and continue in an inclined plane to the surface of the water. The bottom of the aquarium should

be covered with a layer of sand from one to two inches thick, upon the top of which should be placed a few pebbles, in patches. For marine aquaria, the sand must be procured from the sea-beach, or a river-side, below the tide-mark, and, for those of fresh water, from the bed of a brook or running stream, and, in either case, it must be thoroughly washed, to free it from impurities. Rock-work may be built upon the sand, to form caves and grottoes, but there should not be any hiding-places for impurities to collect in. A pleasing effect is secured by building the rock-work above the surface of the water, and making a small hollow in the top, where a fern may be planted. The rock should be taken from the sea, or the brook, according as it is wanted for the marine or fresh-water aquarium, the object being to make the artificial home of the animals as much as possible like their natural one. In constructing the rock-work, Portland cement should be used, and it should be allowed to harden before the water is poured into the tank. The water should be poured off several times, until it remains quite clean, and the greatest care should be taken to prevent the addition of impurities with any object. The plants must be stuck into the sand with a pebble tied to the roots of each to hold it in position, and they should be arranged to produce a pleasing effect, as individual taste may dictate. After the plants have taken root, the animals may be added. If both forms of life be present in proper proportions, there will be no necessity for change or disturbance of the water, but, if they be not, artificial aëration will be required. When this is needed, the

FIG. 3.



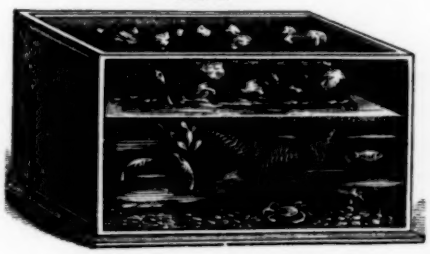
FRESH-WATER AQUARIUM.

fish will repeatedly rise to the surface and stick their noses out to catch a breath of oxygen. Aëration may be effected in lifting the water by cupsful, and allowing it to run back gradually from a point two or three feet above. This process should be continued for a half-hour or more at a time, once or twice a day. The ordinary level of the water should be indicated by a mark on the glass-front, so that loss from evaporation can be detected and supplied. Great care must be taken to secure uniformity of temperature, between 45° and 65° Fahr. For this purpose an east window should be chosen where the sun can be

had for two or three hours every morning. In summer the window should be opened, and in the winter evenings the tank drawn back into the room. A south window may be used for the aquarium if care be taken to shade off the noonday sun. When the water at the bottom of the tank becomes impure from the accumulation of sediment, it may be drawn off by a siphon (of rubber tube) without disturbing the water above, after which the tank must be filled up again with pure water. For the purpose of removing large substances from the bottom, a pair of wooden forceps—glove-stretchers will do—are required. Light particles, such as uneaten food, decayed leaves, etc., can be removed by placing against them one end of a small glass tube, and covering the other with a finger. The aquarium should be kept as clean as possible, all dead plants or animals being at once removed.

The best plants for fresh-water aquaria are the spiral *Valisneria*, a native of Southern Europe, and not easily procurable; the American water-thyme (*Anacharis alsinastrum*); the common frogbit (*Hydrocharis morsus-ranæ*), which, being of different form from the others, will give variety in appearance; the arum (*Calla palustris*); common stonewort (*Chara vulgaris*); water-soldier (*Stratiotes alvidies*); spiked water-milfoil (*Myriophyllum spicatum*); small water-lilies (for larger tanks), white (*Nymphea alba*), and yellow (*Nuphar buteum*). A little duckweed (*Lemna minor*) may be added, as it floats about and harbors minute insects which the fish eat. In choosing animals for the same, the golden carp is most desirable for its beauty, the minnow for interest and longevity. The latter should be examined before admission

Fig. 4.

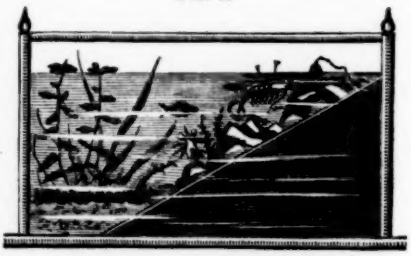


Marine Aquarium (Front View).

and rejected if a white downy spot is observed near the tail, as that is an indication of disease. The loach, the common carp, Prussian carp, roach, tench, and gudgeon, may be admitted, but the first three are preferable to the last. The common tadpole possesses considerable interest in its development into the frog. The small newt and the triton are objects of interest and quite harmless. The latter has a bright-yellow body striped with black. When amphibious animals, such as the newt and frog, are kept, the rock-work must rise above the

surface of the water, as these animals require a resting-place above water. Small floats may be prepared for them by smearing a cork with marine glue and sprinkling it with sand. When the glue has dried, place the float in water and allow it to remain there for some time before putting it into the aquarium. These animals have also a disposition to rove, which must be checked by covering the aquarium. The cover should be of glass and flat, with a large opening in the centre. The cover is also advantageous to keep out dust. Molluscous animals, as the horny coil-shell (*Planorbis corneus*) and the pond mud-shell (*Limnea stagnalis*), may be added. They are both to be found among the grasses that grow in ponds and on the margin of brooks. Such insects as the common water-spider (*Argyroneta aquatica*), the large harmless beetle (*Hydroüs piceus*), and the little whirligig (*Gyrinus natator*), can be introduced to advantage. Pugnacious individuals, as the perch and the stickleback, though interesting, are not desirable objects for a general aquarium. The best food for the animals described is a little biscuit-powder kneaded into pills about the size of a pin-head and fine shreds of raw beef cut with scissors. The first should be fed once a day, the biscuit and meat being thrown in bit by bit alternately.

FIG. 5.



MARINE AQUARIUM (Side View).

The marine aquarium must be supplied with sea-water taken not less than a mile from shore, or from the middle of a large river. When any is lost from the tank *by evaporation*, add fresh rain-water to supply the deficiency; losses otherwise occasioned must be made good by the addition of sea-water. Among the most curious and interesting animals are the shrimp or prawn; the smooth anemone (*Actinia mesembryanthemum*), one of the hardiest and most curious animals that can be found; the limpet (*Patella vulgaris*), with its shelly parasite the barnacle (*Balanus*); the hermit-crab (*Pagurus Bernhardus*); the stone-crab (*Cancer pagurus*); the smaller star-fish; and the tube-worm (*Surpulæ*). In introducing fish, care should be taken to select the most amicable; a small shark, for instance, was once introduced into the aquarium of the Emperor William, at his country-seat in Prussia. The effect was, that all the other fish forsook the tank, and fled in great confusion into a fresh-water one adjoining, nor could they be driven

back until the shark was removed. The best food for the animals indicated is the mussel or the oyster cut into fine shreds, but fresh beef may be used if these cannot be had. To feed the anemones, place a shred upon the end of a stick and put it in contact with one of the animal's tentacles, whereupon it will be immediately conveyed to the mouth. They do not require feeding oftener than once a week. The crabs should be fed at the same time or they will rob the anemones. It is not necessary, as previously indicated, to add plants to marine aquaria; however, a few pieces of sea-weed may be put in for the sake of ornament, but, as it does not live long, care should be taken to remove each piece as soon as it dies, and replace it by a living one.

THERMAL DEATH-POINT OF LIVING MATTER.[1]

By H. CHARLTON BASTIAN, M.D., F.R.S.,
PROFESSOR OF PATHOLOGICAL ANATOMY IN UNIVERSITY COLLEGE, LONDON.

I.

WATER is boiling merrily over a brisk fire, when some luckless person upsets the vessel, so that the heated fluid exercises its scathing influence upon an uncovered portion of the body—hand, arm, or face. Those who have seen much of the effects produced upon the human skin by such accidents, will have acquired information not unworthy of influencing their opinion on some more general problems connected with the action of heat upon living matter. Here, at all events, there is no room for doubt. Boiling water unquestionably exercises a most pernicious and rapidly destructive action upon the living matter of which we are composed. There is no need to appeal to the sufferer's sensations for this information. This, indeed, is a point of view which we may for the present dismiss. For, however agonizing these sensations may be, they could only supply us with information upon a collateral point with which we are not at present concerned. Apart from such subjective effects, there are objective effects. That is, we are easily able to see the changes produced by boiling water upon living matter—revealing themselves as they do by an immediately altered appearance of the skin, and by the terrible wound so quickly produced. Upon these distressing, though, unfortunately, only too familiar consequences of the action of heat upon living matter, it is not necessary for me further to dwell; I would merely have the reader so far bear them in mind that they may not be incapable of recall during the perusal of this article. The occasional revival of such impressions may perhaps prove a little

[1] From author's advance sheets.

instructive to some who may chance to be at all dubious as to the destructive effects of boiling water upon lower organisms.

Probably, however, some of my readers may already be possessed by the notion that the disastrous effects just referred to are consequences following rather from the fact of the high organization of man's tissues than from any intrinsic incompatibility of nature between living matter and boiling water. The thought is natural enough and not unjustifiable. On the other hand, it will not do to attach much importance to it. Let us for a moment consider the effects produced upon an ordinary hen's egg by a brief immersion in boiling water. Here we have the "white," composed of albumen, similar to that which enters so largely into the composition of living tissues, turned from a clear fluid into an opaque solid; and we have the "yelk," made up of a dense aggregation of the simplest living units, also more or less solidified. In spite of the investing calcareous shell, these very obvious and destructive effects can be produced upon this large egg or germ by an exposure for three or four minutes to the influence of boiling water. Yet the living matter in this case is so simple that it possesses next to no organization—it is so little vitalized that it can only be considered to be half alive.

The conclusion would seem, therefore, to force itself upon us that there is something intrinsically deleterious in the action of boiling water upon living matter—whether this living matter be of high or of low organization.

This subject is one of great importance in many respects, so that it may repay us to look into the evidence bearing upon it with some degree of care. It is of great practical importance, for instance, in reference to the process of disinfection by heat, where we have to do with articles of furniture or wearing apparel used by a person suffering from a contagious disease. Because, in such a case, what we ought undoubtedly to know is, whether the temperature of boiling water, or even some lower temperature, suffices to kill any living particles which may act as so-called "germs of disease." This is a subject upon which there should be no room for doubt. Again, from a purely scientific point of view, the question is of equal cogency because of its bearing upon one of the most momentous problems in biological science—namely, that of the Origin of Life. It is on this latter account, more especially, that I now take up the inquiry as to the grade or degree of heat which proves destructive to different kinds of living matter.

A preliminary word of explanation, therefore, must be given concerning the bearings of this question upon the Origin of Life problem.

It is at present very generally admitted, upon the strength of well-known experiments, that living matter will appear and grow rapidly in hermetically-sealed flasks containing certain fluids, after the

flasks and their contents have been thoroughly raised to the temperature of boiling water for ten minutes or more. These experiments we may mentally label as series A. Other experiments, which we may similarly label series B, had also shown that a brief exposure in the moist state to a temperature considerably below the boiling-point of water, is destructive to all kinds of living matter submitted to its influence. The experiments of series A, therefore, taken in conjunction with those of series B, must (if the latter results are as reliable as the former) be held to prove that living matter can originate independently, or *de novo*, through the mere productive properties of certain infusions or solutions.

If the facts are true, is it possible to stave off the conclusion? While the candid reader is asking himself this question, I may further point out to him that, as the previously discredited results belonging to series A are no longer denied, doubt is now only possible upon a subject hitherto supposed to be settled—namely, as to whether living matter is really killed by exposure in the moist state to a temperature of 212° Fahr. Obviously, at such a juncture, it rested more especially with the panspermatists, who chose still to be opponents of "spontaneous generation," to show that this belief concerning the destructive efficacy of boiling water, upon the truth of which they had previously relied, was erroneous—seeing that the advocates of spontaneous generation had demonstrated the truth of their position with reference to experiments A. Should the panspermatists fail to produce this evidence as to the untruthfulness of their old view, they must not expect to hear that they have the best of the argument; and still less will they be able to hold their ground if, while abstaining themselves from all experiments belonging to series B, their scientific opponents do make careful investigations in this direction, and arrive at the conclusion that not only was the old opinion right as to the destructive action of boiling water, but that living matter unaccustomed to the influence of heat is killed by a brief exposure even to the much lower temperature of 140° Fahr.

This is the present aspect of the problem, and those most interested in it may remember that knowledge would not advance in the rapid way which it does, were it not for the fact that the difficulties of one generation of men often disappear before the clearer, because more unprejudiced, vision of the next. Growing gradually more familiarized with the facts, those who come after us will be more and more influenced by them, and at the same time less warped by theoretical considerations already out of harmony with our present state of knowledge. We are now in a stage of transition. We are gradually learning to accept the doctrines of Evolution, as applicable to different departments of knowledge, though, as is so frequently the case when new doctrines are being adopted, this transition is being effected by many in a partial manner—they, unconsciously perhaps, endeavor to make

a sort of compromise, trying to retain some of their most deeply-rooted convictions and mix them harmoniously with new views. Metallic mercury, however, will not mix with water, and there is a similar incompatibility between the explanations of the panspermatists and our present state of knowledge in regard to the question of the Origin of Life.

It remains for me now, therefore, to trace the different steps by which we have arrived at our present knowledge concerning the destructive effects of heat upon living matter. And to do this effectually I must refer my readers to good work done in the latter third of the last century by the acute and learned Abbé Spallanzani, while he was engaged in promulgating panspermatist doctrines against the views of our own countryman Needham, who, in those days, steadfastly proclaimed the truth and reality of "spontaneous generation"—though the philosophical doctrines by which he was influenced caused him to limit the acceptation of the phrase to what we now understand by the term *heterogenesis*.

I refer first of all to the work of Spallanzani, partly because he alone, of all those who have adopted panspermatist views and have taken part in this controversy, has fairly and fully faced the question of the degree of heat which proves fatal to various living things, by making it the subject of direct investigation. Others who have since defended similar views (including Pasteur in France, and Huxley and Sanderson in this country) have not made the thermal death-point of living matter a special subject of investigation, and have more or less distinctly confounded the issues of this question with that of the cognate though really distinct problem, as to whether certain infusions could themselves prove mother-liquids, and give independent birth to living matter. Dire confusion has thus been produced. A problem of a very simple nature has been made to appear very complex, while those who are able clearly to understand the real nature of the question at issue are left to marvel why the followers of Spallanzani have never ventured frankly to deal with the question of the limits of vital resistance to heat. Certainly they have displayed, to say the least, a strange sluggishness in reference to this exceedingly important problem. But apart from the fact that no panspermatist, or declared opponent of spontaneous generation, since the time of Spallanzani, has fully and directly experimented upon this subject, I am all the more induced to call the reader's attention to the abbé's treatment of it because, with some few exceptions, his investigations were conducted in a manner which cannot be improved upon at the present day, and because his reasonings upon the subject are characterized by great sagacity and fairness—allowance being made for the actual state of knowledge in his time. The work of the learned abbé to which I shall especially refer is entitled, in the admirable French translation by

Jean Senebier, "*Opuscules de Physique, Animale et Végétale*," the translation itself having been published at Geneva in 1767.

Reflecting upon the import of the experiments of his own that he had just recorded, in which living organisms were found in closed vessels containing infusions of certain vegetable seeds after these closed vessels had been immersed in boiling water for half, or, in some cases, nearly three-quarters of an hour, Spallanzani frankly avows (p. 48) that if the first of the new organisms had not come into being by some such independent method as that suggested by Needham, they must have appeared either because certain "germs" from which they had been derived had been able to resist the destructive influence of boiling water for nearly three-quarters of an hour, or because, after the cooling of the closed vessels, some of the organisms observed had passed from the air through certain imaginary pores of the glass. At the first glance these seemed, as he says, "deux suppositions également impossibles, ou du moins très difficiles à concevoir." For very excellent reasons, not difficult for the reader to imagine, the abbé then points out that the latter hypothesis, at all events, is entirely untenable. The question thus became one of the simplest description. If no good reason could be found in support of the seemingly improbable supposition that the experimental results referred to were to be accounted for by a survival of germs, then, as he confessed, he must admit the fact of an independent and germless origin of living things. If, on the other hand, it should appear probable that germs or reproductive particles of living things could survive the influence of such a prolonged immersion in boiling fluids, he would not feel at all bound on the strength of his previous experiments to believe in the independent origin of living matter. This simple issue was fully realized by Spallanzani, and, acting in accordance with the most obvious of scientific principles, he carefully sought for fresh evidence by means of well-directed experiments, in order to guide him toward a conclusion as to whether germs of living things could or could not have resisted the action of boiling water for more than half an hour.

He approached the question in the following manner: "Can one," he says, "find any proof sufficient to banish, or, at all events, to diminish one's natural repugnance to admit that the germs of animalcules of the lowest order have the power of resisting the action of boiling water? In reasoning from the germs or eggs of animals with which we are acquainted, would it be difficult for us to imagine animalcules having this peculiarity? It is true that we are not acquainted with any eggs endowed with such properties. I have already considered this subject in the ninth chapter of my Dissertation. I there show how several kinds of eggs of insects—not to speak of eggs of birds—perish under a heat less than that of boiling water. I have shown also that the seeds of plants are destroyed when they are exposed to the heat of boiling water, and that even those whose outer coat is of the

hardest description are not thereby spared." But he goes on to say, as he had only been able hitherto to make his observations on a limited number of eggs and seeds, there was the chance that more extended observations might reveal some capable of resisting this generally destructive influence. He says he had never lost this hope, with regard to seeds more especially, since he had seen a statement by Duhamel to the effect that some grains of wheat had germinated after having been heated in a stove to a temperature above the boiling-point of water.[1] And as there is a considerable resemblance between seeds and eggs, Spallanzani was led to hope that something of the same alleged extraordinary capacity for resisting heat might be possessed by the eggs or germs of such organisms as make their appearance in previously boiled fluids. He was therefore stimulated to undertake fresh observations upon eggs and seeds generally, with the view, on the one hand, of ascertaining the precise temperature which proved fatal to each kind, and, on the other, of finding out whether these eggs or seeds were capable of resisting a greater degree of heat than the several animals or plants to which they belonged.

This latter part of the inquiry was rightly deemed by Spallanzani to be of great importance and capable of affording him much guidance toward the proper interpretation of his other experiments. He had already determined that the lower infusoria themselves are killed at a temperature of 34° Réaumur, or 108½° Fahr.; and now having found that such organisms would appear within closed vessels previously subjected to a temperature of 212° Fahr., owing, as he was inclined to think, to a survival of their germs, Spallanzani was anxious to ascertain whether he could gain sufficient support for this hypothesis—that is, whether the difference in the capacity of resisting heat, imagined to exist in this case between parents and germs, could be justified by the establishment of similar differences in heat-resisting capacity between other parent organisms and their germs.

In carrying out these inquiries, Spallanzani adopted the following method (p. 53): He placed the eggs, seeds, or organisms, in a vessel containing cold water, into the upper strata of which was immersed the bulb of a thermometer. The water was then heated slowly, and when the thermometer indicated that the temperature had been attained, whose effect it was desired to test, the eggs, seeds, or organisms, were at once withdrawn and placed, under suitable conditions, in a separate vessel. The effects of different grades of heat upon the

[1] Heated in all probability in the dry state. But it is well known that seeds and desiccated animals can resist the influence of heat much better in the dried state than when they are thoroughly moistened and then heated, and it is as to the effects of heat upon living matter under the latter conditions with which we are at present concerned. For this reason, therefore, I shall not dwell upon those experiments of Spallanzani, in which he heated seeds in the midst of dry sand—these experiments lie outside the boundaries of our present inquiry.

objects experimented with were thus estimated, and the temperature in successive trials was mostly made to differ from that last employed by 5° R. Operating in this way, and, in the case of eggs or seeds, subsequently taking great care to place those used in the different trials under similar conditions, alike favorable for germination or development, Spallanzani obtained the following results:

Of frogs' eggs only an extremely small number developed after having been simply raised to the temperature of 131° Fahr., while not one developed which had been heated to 145° or upward. Tadpoles produced from similar eggs all perished at 111°, and the same temperature likewise proved fatal to the parent frogs from which the eggs had been derived, as well as to aquatic salamanders and to fish with which experiments were made.

Silk-worms' eggs, and the eggs of the elm-moth (Papillon de l'Orme), developed less and less frequently when successive batches were heated to temperatures approaching 144½°. When they were actually submitted to this heat, all perished, though the highest temperature followed by development is not recorded. Silk-worms themselves, as well as the caterpillars of the elm-moth, were uniformly killed as soon as the water in which they were immersed attained 108½°.

Eggs of the common blow-fly only developed in very small numbers when raised to the temperature of 135°, while all perished at 140°. The larvæ developed from these eggs all died, as those of the silk-worm and elm-moth had done, as soon as the temperature of the water rose to 108½°. Other adult larvæ, of the same species with which experiment was subsequently made, perished at the same heat.

In addition, Spallanzani experimented with some aquatic organisms, though he was unable to discover, and therefore to experiment with, their eggs. Thus leeches perished at 111°, and the Nematoids known as "vinegar-eels" at 113°. Other aquatic worms were killed at 111°, while water-fleas died at 107°.

So far, therefore, Spallanzani's results were most uniform; the different kinds of eggs were killed by mere momentary exposure to a temperature of about 140° Fahr., while the animals to which they were related perished at or about 110°.

The abbé next turned his attention to the power possessed by plants and their seeds of resisting the action of heated water. These observations were conducted in the same manner, though only the roots of the plants were immersed in the water while it was being heated. The plants were afterward carefully replaced in earth. Much care was taken when the seeds were sown to keep the batches distinct from one another, and to place them as much as possible under the influence of similar conditions.

Spallanzani's first experiments were made with the seeds of the chick-pea, lentil, wheat-grass, flax, and clover. The water was heated slowly, and the seeds were taken out as soon as the desired tempera-

ture was attained, so that there was only a momentary exposure to the temperatures about to be cited. Of those which had been exposed to 190° Fahr., many did not germinate; still fewer of the seeds that had been exposed to 201° produced young plants, while, of those heated to 212°, not one germinated. After the young plants (developed from seeds heated to lower temperatures) had grown for thirteen days, their capability of resisting heat was tested in the manner described, and with this result. Those whose roots had been momentarily exposed to 156° continued to live after they had been replanted, while those whose roots had been exposed to 167° and upward speedily dried up and perished, although, like the others, they had been replanted in carefully-watered earth.

These were the only complete experiments made by Spallanzani with plants and their seeds; but many other kinds of seeds only, including those of the broad-bean, barley, kidney-bean, maize, vetch, spinach, beet-root, turnip, and mallow, were also exposed to the influence of heat while packed in dry sand. Although this method is less exact and trustworthy, and is one with which we are not now concerned, still it may be stated that only four of the numerous seeds with which experiment was made after this fashion survived their brief exposure in the dry state to the temperature of 212°; all the others failed to germinate.

The abbé's researches, therefore, taught him three things: 1. That eggs can endure a decidedly higher degree of heat than that proving fatal to animals of the kind from which they have been derived; 2. That an analogous difference exists between seeds and plants in respect to their capacity of withstanding the action of heat; and, 3. That seeds and plants can resist higher grades of heat than eggs and animals respectively.

After calling attention to these conclusions, Spallanzani said (p. 64): "Of course I am far from pretending to explain these results; I know the difficulty of the undertaking, and will only venture a few conjectures, at most, letting them go for what they are worth, and leaving every one free to think as he pleases." As his conjectures, however, cannot be much improved upon at the present day, I may as well call the reader's attention to them by briefly pointing out their nature.

At the first glance, the abbé says, the superior power of resisting heat displayed by eggs and seeds, as compared with animals and plants, might be supposed to be due to the latter feeling the effects of heat more rapidly, owing to their being free from those envelopes which inclose the egg or the seed. But the weight of this supposed reason soon disappears, in the case of eggs at all events. Looking to the thinness of their investing membrane, this supposition, as Spallanzani says, "seems very improbable indeed, when we consider how easily and how rapidly fire penetrates so thin a layer of matter." He

quickly dismisses, as even more improbable, the notion that the smallness of the germ or egg can act as its safeguard by rendering it less amenable to the influence of heat. Having thus cleared the ground, Spallanzani states what seems to him to be the principal reason of the difference observed. We ought to reflect, he says, upon the difference between the life of an animal in its egg stage and its subsequent life as a developed organism. For, however deficient our knowledge may be upon this subject, we may feel assured that life shows less of the characters of life in the egg than in the organism which is born from it. The life of the egg is "very feeble"—"its life has less of life." And then Spallanzani asks whether the fact of this life of the embryo within the egg being "so small and so feeble"—being "a life which deserves so little the name of life"—may not be the reason that eggs are able to bear the influence of heat better than the developed organisms whose life is more active and complex? He believes this to be the principal reason of the increased power of resisting heat displayed by eggs, and in support of it calls attention to the fact that many animals (as well as plants), when the rate of their vital phenomena is lowered, during winter sleep, are much better able to withstand many injurious external influences than when they are displaying to the full all the manifestations which constitute their "life." Animals, such as frogs and salamanders, for instance, live longer after and resist the effects of injuries better, when they have been incurred during the benumbing cold of winter rather than at periods when these organisms have been full of life and activity.

A similar difference obtains between the degree and complexity of the life of seeds as compared with that of plants, and this difference may in part similarly explain the superior power of resistance to heat shown by seeds—since here, also, among plants, we find that ability to withstand hurtful influences, generally, increases as their life becomes more sluggish. Thus Spallanzani says, "One may say that in winter plants live less fully than at other seasons, and during this period they are also much less liable to perish when they are plucked from the ground or unduly pruned, than if they had been treated in the same manner during summer."

Again, while a difference of the same kind may in part be cited as the cause of the less injurious effects of heat upon seeds and plants as compared with that which it exercises over eggs and animals respectively, Spallanzani points out that this difference between eggs and seeds is only in part due to the fact that the outer coats of most seeds are much harder than those of eggs, since the envelopes of some seeds which are only killed at a temperature near 212° are not harder than the shell of an egg which is nevertheless killed at the much lower temperature of 140° Fahr. This difference is explicable rather, according to Spallanzani, by the fact that the fluids contained within the egg are so much more abundant than those within the seed. In cases of

short exposure to heat the animal embryo is thus more easily killed than the vegetable embryo, because its greater moisture causes it rapidly to experience the full effect of the heat, which the seed may possibly escape.[1]

Now, then, for the application of the facts, toward the interpretation of Spallanzani's other experiments in which the lowest organisms appeared in closed flasks whose contents had been exposed to the temperature of boiling water for half an hour. Certainly the germs of such animalcules could not be supposed to have survived such an ordeal if they are to be compared with the eggs of animals, whose death has been brought about by momentary exposure to a temperature far short of the boiling-point. The supposition would, however, seem more possible, if, instead of comparing these germs with the eggs of animals, one regarded them as belonging to the same category as the seeds of plants. Spallanzani frankly admits that they would seem to be more allied to eggs than to seeds, though he attempts to bridge the gap by saying that certain eggs are known (to which these germs may be allied), in some respects resembling seeds. Such eggs "become dry, are preserved in this state, and then develop like seeds after they have been placed in some damp medium. . . . Why, then," he adds, "may not the germs of the lowest kind of animalcules be possessed of a similar nature?" He next (pp. 69–73) adduces various considerations which led him to consider this view as more and more probable, though none of them would be regarded as very relevant by physiologists of the present day. The space at my disposal will not permit of my following him into these details—the reader curious on this subject must therefore consult Spallanzani's work for himself.

The position of things about a century ago, therefore, was this: Not a single living thing, egg, or seed, had been shown to be able to resist, when in the moist state, an exposure to boiling water for a single moment. All naturally moist forms of living matter with which experiment had been made had been shown to be killed by a much lower heat, that is, at a temperature of about 140° Fahr., or less. And, in order to account for the appearance of the lowest animalcules in previously-boiled fluids, Spallanzani assumed—1. That these unknown germs were of the nature of seeds rather than eggs—seeing that they were capable (as he supposed) of undergoing desiccation with impunity,

[1] Spallanzani's argument thus naturally suggests the notion that many of the seeds with which he experimented required a high temperature to kill them, merely on account of their dryness. If the seeds had been well soaked in cold water beforehand, so as to have thoroughly moistened them, might they not have been killed at a much lower temperature—that is, only a little, if at all, above 140° Fahr., or the temperature which proved destructive to the more moist animal germs? Facts which will be subsequently mentioned, since ascertained by Max Schultze and Kühne, would seem to render this very probable, and compel us to regard Spallanzani's experiments with seeds as needing repetition with the modification above suggested. The plants also, like the animals, should have been wholly instead of partially immersed in the heated water.

and that this dryness conferred upon them the greater power of resisting heat which characterized seeds. Nay, further—2. Although no seeds could be shown to be able to resist the influence of boiling water, Spallanzani assumed that these unknown seed-like germs might be able to do so. Thus alone was he able to continue in the panspermatist faith—on the strength of these assumptions only, could he refuse assent to the probability of a germless origin of living matter, more or less after the fashion suggested by Needham and others. It will, therefore, be interesting for us now to consider how far the progress of science tends to confirm or reverse Spallanzani's assumptions.

MENTAL PHYSIOLOGY.

By Dr. J. C. BUCKNILL.

AN important work on the above subject, by a man so eminent and so various in science as Dr. Carpenter, cannot fail to attract the attention and to be worthy of the study of all those whose work in life is to prevent or restore mind from its morbid conditions, and who fully appreciate the necessity of building the edifice of Mental Pathology upon the sure foundations of Physiological Science.

The history of the work before us is told us by the author in his preface. It has grown out of the interesting and suggestive chapters on Psychology, which formed part of the fourth and fifth editions of his "Principles of Human Physiology." It is, however, more than a physiological treatise. It is an attempt to reconcile the facts of science with the reasonings of philosophy, to bridge over the abyss which yawns between materialism and immaterialism, to find some standpoint for free-will, morals, and responsibility, within touching distance of the brain-cells. Quoting from Charles Buxton's "Notes on Thought," the author says:

"Irresistible, undeniable facts demonstrate that man is not a den wherein two enemies are chained together; but *one being*—that *soul and body are one*—one and indivisible. We had better face this great fact. 'Tis no good to blink it. Our knowledge of physiology has come to a point where the old idea of man's constitution must be thrown aside. To struggle against the overwhelming force of Science, under the notion of shielding Religion, is mere folly."—(*Preface*, p. xiii.)

It is not always certain, when language like the above is used, whether the writer intends to affirm that the body is the soul or the soul is the body, for there is confusion in using two words for one thing, and especially two words which through all the ages of thought have been held to express such opposite meanings. In a work on physiology, however, it is the body and its functions which have to be

discussed, and we should have been glad to have found that the body, and the body alone, was the subject of this most learned treatise. Such, however, is very far from being the fact, for, although Dr. Carpenter enters into no ontological discussions, and rarely mentions the soul under its old name, it is present in most pages of his book under the designation of Free-Will. Free-will it is which is the foundation of morals, which renders man responsible for his actions, which gives him the power of forming his own character, which rules and dominates, or at least ought to rule and dominate, all the emotional and intellectual functions of the brain which science shows to be the result of animal chemistry. The autocratic power of the will is the key-note of the whole book, or the red thread which runs through all its pages, as that royal mark does through the ropes and cables of Chatham. Memory is a function of the brain, and so also is judgment, and desire in all its hues, but the will is free, if you will only let it be so; free from the embarrassment of corporeal imperfection, and capable of directing and ruling the senses, the passions, and the reason to all the ends and purposes which good theologians portray as the right aspirations of the soul.

Dr. Carpenter states that—

"According to the view which it has been *the special purpose of this treatise to develop*, the relation of the will to mental is essentially the same as that which it has to bodily action. The measure of its exertion will be the sense of effort which we experience in *intentionally* exciting, directing, or restraining any particular form of mental activity" (p. 138).

The will, therefore, can direct the mind as it can direct the muscles. It can order the attention, and

"Can detach its subjects, which have at the time the *greatest* attractiveness for it, and can forcibly direct it to others from which their attraction would otherwise divert it" (p. 38).

If this be true, the Will exists and is free. But is it true? Can any human being intentionally choose the lesser desire, all things being considered, and all forces outside the so-called will being estimated? This great, greatest perhaps of all questions, is answered by Mr. Mill, and all the determinists, in the negative. Dr. Carpenter takes the opposite view, and founds his mental physiology upon his opinion. He thinks the will is self-determining, and capable of choosing to be influenced by the smaller attraction, and this constitutes its freedom. But if the will exists, and is free, what is it? Certainly not merely the "determinate effort to carry out a purpose previously conceived," as the author in the first instance defines it; for this bare determinate effort is the very idea of it propounded by the most logical necessitarian determinists. It is far more than this.

"We have now, however, to consider a much more obscure question, namely, the *nature* of the *self-determining agency* to which we give the name of Will.

Is it, as some think, the mere resultant of the general (spontaneous or automatic) activity of the mind, and dependent like it upon physical antecedents? Or, is it a power which, being completely independent of these conditions, is capable of acting *against* the preponderance of motives?—as if, when one scale of a beam is declining downward, a hand placed upon the beam from which the other scale is suspended were to cause that lighter scale to go down. Now, that the will *is something essentially different* from the general resultant of the automatic activity of the mind, appears to the writer to be proved, not merely by the evidence of our own consciousness of the possession of a *self-determining power*, but by observation of the striking contrasts which are continually presented in abnormal states of the mind between the automatic activity and the power of volitional control (i. e., in toxic delirium), while the weakening of that power, usually in concurrence with an exaltation of some emotional tendency, is the special characteristic of insanity."

Dr. Carpenter proceeds to show how the will can override reason and judgment, in questions either of intellectual or moral truth, by keeping some considerations out of view and by fixing the attention upon others; so that in this manner the will determines the balance of evidence which commands belief, as it does the balance of evidence which determines conduct. It is, perhaps, superfluous to observe that this self-determining power which rules the senses, guides the opinions, directs the judgment, and controls the conduct of men, which is something essentially different from the general activities of the mind, and is completely independent of physical antecedents, cannot be a physiological, and therefore must be a spiritual power. And this notion agrees with what we have read in other places than Dr. Carpenter's book on Mental Physiology, and where it has caused us less surprise. Granted—we have seen it stated—that perception, memory, emotion, judgment, and all other activities which you more or less successfully demonstrate to be functions of the brain are so in fact, still there is the will. In what ganglion or convolution will you locate that? What influence has the chemistry of the little cells upon that prime motive power? What can change of structure effect there?

It is autocratic, self-dependent, and, excepting in itself and by itself, unchangeable. It is at least a spiritual force with which body has naught to do. It is the heavenly part of man. It is the soul.

The theological bearings of the question will be somewhat out of place in these pages, but it is worth while to remark that the absolute freedom of the will does not fit in with some systems of theology which are tenaciously held by large numbers of Christians.

Let those who think that there can be no morality and no religion, no foundation for human responsibility, and no basis for a moral code, without freedom of the will, read the great work of that grand old Puritan divine, Jonathan Edwards, entitled "A Careful and Strict Enquiry into the Modern Prevailing Notions of that Freedom of the Will which is supposed to be essential to Moral Agency, Virtue and

Vice, Reward and Punishment, Praise and Blame." Romans, ix. 16, "It is not of him that willeth." Edwards, who has been well compared for his philosophic acumen to our own Berkeley, maintains that—

"The decision of most of the points in controversy between Calvinists and Arminians depends upon the determination of this *grand article* concerning the freedom of the will requisite to moral agency."

He argues that God's moral government over mankind is not inconsistent with a determining disposal of all events of every kind throughout the universe.

"Indeed" (he says) "such a universal determining Providence infers some kind of *necessity* of all events—such a necessity as implies an infallible previous fixedness of the futurity of the event; but no other necessity of moral events, or volitions of intelligent agents, is needful in order to this than *moral necessity, which does as much to ascertain the futurity of an event as any other necessity.* As to freedom of will lying in the power of the will to determine itself, there *neither is any such thing*, nor any need of it, in order to virtue, rewards, commands, counsels," etc.

The theology of the most numerous, and, perhaps, the most earnest, sect of Protestant Christians is shown to be utterly adverse to the doctrine of free-will, and it would be equally untrue and uncharitable to deny that the lives of millions of persons guided by these opinions have proved from the Reformation to this hour that the opinion that neither will, thought, nor conduct is free, is consistent with a strict morality.

We have, perhaps, written more than enough for these pages on "the special purpose" of Dr. Carpenter's work, namely, the development of the theory that, although the mental functions generally are automatic, the will is free. The theory, so far as we can ascertain, is not sustained by any facts fit to sustain an argument of such weight. The assumed fact that we are conscious of freedom and power to act in accordance with our moral judgment is revealed in face of the contradiction which it constantly receives, for the sense of restraint said to be felt by one is at least equivalent to the sense of liberty said to be felt by another. It is even more appreciable. A bird may think itself free to fly where it lists, yet, when dropped from a balloon, it falls like a stone. Any captive may think himself free until he get to the bounds, and the freest of us all is still a captive—

"And drags at each remove a lengthening chain."

THE TRAVELLER.

"The tendency of the human free-will is to fly upward," writes our author. "It is by the *assimilation* rather than by the *subjugation* of the human will to the Divine that man is really lifted toward God; and in proportion as this assimilation has been effected does it manifest itself in the life and conduct, so that even the lowliest actions be-

come holy ministrations in a temple consecrated by the felt presence of the Divinity" (p. 428). This, however, is not physiology.

Outside the narrow circle where Dr. Carpenter treads the barren heath of metaphysics, tethered to his theory of free-will, lies the wide and beautiful world of Nature which no one knows better than himself. Naturalist, physiologist, philosopher, philanthropist, there are few men who touch Nature, and human nature, at so many points; and there are very few who can illustrate their knowledge from such rich stores of reading and research.

We are not surprised, therefore, to observe an important journal speaking of Dr. Carpenter's new book as being "as amusing as a novel." Not that novels always are amusing, or that amusement is a proper aim for a scientific work, yet the wealth of illustrative anecdotes scattered through these pages seems to justify the intended compliment of the *Lancet* reviewer. The thought, however, most impressed upon ourselves by Dr. Carpenter's wide acquaintance with men and books, and the use he has made of it in his abundant illustrations of mental phenomena, is that these phenomena are in their very nature so transitory and fluent that they afford most unsatisfactory data for scientific conclusions. Physical facts can be repeated and verified. Even facts of rare occurrence and beyond the control of man do repeat themselves, and can be waited for. The astronomer, or at least astronomers, can wait for the next transit of Venus, or the next appearance of a comet; but who can be expected to wait for the man capable of "repeating correctly a long act of Parliament, or any similar document, after having once read it?" (p. 457); or of that distinguished Scotch lawyer who performed a feat of legal ratiocination while he was asleep, which had baffled the utmost exertion of his waking powers (p. 593). These cases are quoted by the author on the respectable authority of Abercrombie, who recorded them forty years ago, and the time for their repetition has perhaps not yet come full circle round.

Without the opportunity of a verification, men are apt to accept marvelous statements as to mental facts with a degree of indulgent faith which they would never extend to any physical feats or phenomena. No one would accept the statement that a man had run a mile in two minutes, but that a man had performed a prodigious feat of cerebral exertion far surpassing, in comparison with the average powers of man, the excess of power which this would indicate, will gain ready credence, and find record in repetition without end. We should rather have expected that Dr. Carpenter, dealing with the faculties of mind from the scientific point of view, would have had more vividly before him than appears this peculiarity of the evidence on his subject, and that he would have preferred to choose the commoner and more verifiable facts than the curiosities of mental literature; that he would have directed his research rather to the ocean-currents of

mind than to the record of occasional floods, transient eddies, and doubtful whirlpools. His method in this respect, we think, is somewhat defective, and method in such a matter is of the very essence of the investigation.

One noteworthy whirlpool of deception and credulity, namely, spiritualism, Dr. Carpenter has investigated here and elsewhere with great care—not, perhaps, so much in reference to the wild turmoil itself, as to the manner in which innocent chips and straws are whirled round on its surface, or engulfed in its depths. He has shown how much and how far persons of a certain constitution may, by automatic action of muscle, nerve, and brain, be the dupes of their own imperfect organization, and the puppets of stronger and more vulgar minds. We could have wished that the peculiarities of extra-automatic people could have been investigated by themselves, and in a strictly scientific manner, and without according the undeserved honor of inquiry to those who travesty the wholesome laws of Nature, convert a fit into a heavenly trance, an hysterical girl into a prophetess, an automatic movement into a communication with the spirits of the dead. We scarcely think that the one grain of truth was worth sifting from all those bushels of chaff and rubbish. Perhaps no one who was not thought to be open to conviction in these matters would have been permitted to look behind the foot-lights, and if Carpenter had spoken sharply and bluntly, as Faraday did of the table-turners, his opportunities for investigation might have been greatly curtailed. As it is, Dr. Carpenter has done rare service in this cause now and aforetime.

Dr. Carpenter states that the number of persons capable of being biologized is "from one in twelve to one in twenty; so that, in a company of fifty or sixty persons, there are pretty sure to be two or three who will prove good biological subjects." We apprehend that a very wide margin must be left for the effects of deception and credulity even in the simple process of biologizing. We never saw a lunatic biologized, and we have seen a hundred experimented upon by professors of the art. In as many school-girls probably a large proportion would be found susceptible, especially if they had been ill supplied with good food and fresh air, and had imbibed an undue amount of sensational poetry and fiction. One lady Dr. Carpenter has himself biologized into so deep a sleep that she could not be awakened by any ordinary means, even by being roughly shaken. "Her slumber appeared likely to be of undefined duration; but it was instantly terminated by the operator's voice calling the lady by her name in a gentle tone." What assurance, however, can the doctor have that this young lady was not playing a trick upon him, or simply indulging a caprice? It is always wise to try the simplest explanation first, and in women the capricious is certainly more common than the biological temperament, even if the author's statistics of the latter be correct.

The warning against these experiments, which are too much the pastime of the idle, the hysterical, and the foolish, is of weighty import:

"The undue repetition of such experiments, however, and especially their repetition on the same individuals, is to be strongly deprecated; for the state of mind thus induced is essentially a morbid one, and the reiterated suspension of that volitional power over the direction of the thoughts, which is the highest attribute of the human mind, can scarcely do otherwise than tend to its permanent impairment" (p. 565).

The question of "Unconscious Cerebration" or "Latent Mental Modification," which is peculiarly Dr. Carpenter's own, is too important and unsettled to be fully discussed within the brief limits of a review. Dr. Carpenter thinks that his views had been anticipated by Sir William Hamilton, but the passage he quotes from that philosopher scarcely appears to us to detract from the author's priority of thought. Sir W. Hamilton's "mental activities and passivities of which we are unconscious, but which manifest their existence by effects of which we are conscious," are plainly indicated by the sentence which follows as referring to the unknown and the incognizable. We are conscious of the knowable, unconscious of the unknowable.

"There are many things which we neither know nor can know in themselves, but which manifest their existence indirectly through the medium of their effects. This is the case with the mental modifications in question. They are not in themselves revealed to consciousness, but as certain feats of consciousness; suppose them to exist, and to exert an influence on the mental processes, we are thus constrained to admit as modifications of mind what are not phenomena of consciousness" (p. 518).

Hamilton proceeds to explain that we can only be conscious of a determinate state or mental condition which supposes a transition from some other state: "But as the modification must be present before we have a consciousness of it, we can have no consciousness of its rise or awakening, for this is also the rise or awakening of consciousness."

If all this means any thing, it must mean that we are only conscious of mental states which exist at the time, and that we are unconscious of preceding mental states, or of the transition from preceding to existing states. How Dr. Carpenter can hatch unconscious cerebration out of that egg we cannot imagine.

Neither can we see how John S. Mill can be thought "explicitly to accept the doctrine of unconscious cerebration," seeing that he "considers unconscious mental modification as a contradiction in terms; attributing the phenomena to unrecognized changes in the substance of the brain which he regards as the constant physical attendants of mental modifications."

No doubt there are many brain-changes of which we are not conscious, but mental change, without consciousness, is, according to this

very high authority, a contradiction in terms. But all the facts adduced by Dr. Carpenter to prove unconscious cerebration are distinctly mental changes such as, according to Mill, it is a contradiction in terms to designate as unconscious.

These mental changes may be classed almost entirely under two heads: 1. Recollection without effort; and, 2. Apparent increase in the results of thought without further thought.

It may be taken as one of the commonest mental experiences of most men, that a fact, and especially a name, which they endeavor to remember, which escapes from the determinate effort of recollection, often suddenly jumps, as it were, into the recollection without effort, after they have been thinking of other matters. Dr. Carpenter explains this by the theory that the part of the brain engaged in storing up and reproducing past impressions is not the same part of the brain which is engaged in the consciousness of those impressions, or in the consciousness of their reproduction; and that after the seat of consciousness has given up its futile labor, the seat of memory unconsciously continues its activity, and when it has unconsciously brought its work to a successful issue it communicates the result to the seat of consciousness; then, and not before, the fact is consciously remembered. Upon this we must remark that the conscious effort to command the memory, without guide or clew, is generally and singularly unsuccessful in result. The only way to succeed in remembering some forgotten thing is to seek some clew, some thread of ideal association which may lead us to it. The direct bald effort fails, for the simple reason that the attention is fixed upon the effort, and not upon the idea sought. Withdraw the effort, and the attention fixes upon the idea. The memory of the thing was in the brain, must have been there all the time, or it could never again have been remembered. Memory is a latent power, and always unconscious. Recollection is the mental activity which opens the cells of memory to the consciousness and recollection, therefore must always be conscious. That any portion of brain-work is done unconsciously in the act of recollection, is a theory to which we cannot subscribe without far stronger evidence than any which we have yet seen adduced.

The second class of facts adduced to prove that mental work can be performed by the brain without consciousness, are almost as common among men who are in the habit of employing their minds in intricate and difficult subjects. A man thinks on some matter which needs to be considered from various points of mental view, which appears to have bearings on many other subjects which seem to need elucidation from many quarters; he turns all the mental material over and over again until the whole business seems a jumble, and, in confusion and weariness of thought, he puts it aside. He sleeps upon it, and the next day that which overnight was a daub of confused colors, is seen as a bright and clear mental picture. The instances

adduced by Dr. Carpenter of this mental phenomenon are varied and exceedingly interesting, but we suppose that no reader of these pages will have any difficulty in referring such experience to himself. But, affirming the facts, will he also agree with the explanation that this power, of seeing old thoughts in a new light, is due to work which the brain has been doing in the mean time, while he was unconscious of its activities? The brain has been doing work, no doubt. It has been replenishing its forces by rest and nutrition. But has it been performing acts of memory and ratiocination? Has it been sifting away the chaff of irrelevant material, and retaining the grain of reason, and the possessor of the brain all the while unconscious of these mental activities? If so, Dr. Carpenter's theory of unconscious cerebration is a new, original, and most important light on the nature of mental activities. But if the power of looking at things anew, of considering arguments afresh, giving irrelevances the chance of being forgotten, and essentials the opportunity of being duly weighed, if this results in the better and clearer understanding of the subject of thought from the simple fact that the mere effort of thought is made under great advantage over the old, then the theory would seem to be unnecessary and superfluous. We think of fishing to-morrow, and pull out fly-books and materials, and are entangled in a medley of feathers, silks, and lines. In the morning we put up our rod, and, with a cast of flies suited to the weather, we seek the stream. Was the mind all night, being unconscious, arranging that which bothered us so in the evening? So with the materials of ratiocination; we begin by collecting from all sides that which may be needful, and the mind becomes perplexed and confused, until the time for decisive thought or action comes, and then we take those things only which are needful.

Dr. Carpenter's theory of unconscious cerebration is in accordance with what we may call his regional physiology of the brain. He places the higher psychical functions in the convolutions of the cerebrum, but the cerebral ganglia or the sensorium is the seat of our consciousness of these functions, as it is that of external sensations, but of that class of "*truly* subjective sensations" which comes to the sensorium, "the result of changes in that cortical layer of the cerebrum which we have reason to regard as the seat of the higher psychical operations." When the psychical operations of the cerebrum have been reflected downward upon the sensorium, they become subjective sensations, and give rise to the formation of an *idea*.

"It is the *sensorium*, not the cerebrum, with which the will is in most direct relation; and in order that this doctrine (which lies at the basis of the whole inquiry as to the relation of the will to motives, and the mode in which it determines our character and actions) may be rightly apprehended, it is necessary here to consider the following physiological question: Whether cerebral changes are in themselves attended with consciousness, or whether we only become conscious of cerebral changes as states of ideation, emotion, etc., through the in-

strumentality of the sensorium — that is, of that aggregate of sense-ganglia, through the instrumentality of which we become conscious of external sense-impressions, and thus feel sensations?" (p. 109).

"In this point of view the sensorium is the one centre of consciousness for visual impressions on the eye (and by analogy on the other organs of sense), and for ideational or emotional modifications on the cerebrum—that is, in one case for sensations, when we become conscious of sense impressions; and, in the other, for ideas and emotions, when our consciousness has been affected by cerebral changes. According to this view, we no more think or feel with our cerebrum than we see with our eyes; but the *ego* becomes conscious through the same instrumentality of the retinal changes, which are translated (as it were) by the sensorium into visual sensations, and of the cerebral changes, which it translates into ideas and emotions" (p. 111).

It would be impossible to put in clearer language this new doctrine, the psychical and the physiological counterparts of which are thus made to fit so accurately and consistently. The first question, however, which ought to have been entertained is the basement of physiological fact upon which all this imposing edifice has been erected. We are not aware of any, over and above the experiments of Flourens, who showed that birds performed consensual movements, apparently indicating the retention of consciousness, after the cerebrum had been removed down to the optic thalami and the corpora striata. But in complement to these interesting experiments, we have the fact that frogs perform consensual movements which may be taken to *indicate* the retention of consciousness after the spinal cord itself has been divided. The movements of Flourens's pigeons no more prove the retention of consciousness than those of a decapitated frog, which "when acetic acid be applied over the upper and inner part of the thigh, the foot of the same side will wipe it away; but if that foot be cut off, after some ineffectual efforts, and a short period of inaction, the same movement will be made by the foot of the opposite side" (p. 68).

If, under the light of these facts, it be difficult to maintain that the seat of consciousness is not diffused through the central parts of the cerebrum *and* of the spinal cord, the pathological fact that in the human being the optic thalamus or the corpus striatum may be fundamentally changed in consistence and structure by disease, without loss of consciousness, is a barrier against the acceptance of Dr. Carpenter's theory, which, as yet, we are unable to make our way over, under, or through; and, at present, our conclusion is, that unconscious cerebration is an hypothesis all in the air, and unsupported by any foundation of physiological fact.

Whether the activities of the cerebral convolutions are unattended with consciousness until they have been reflected upon the sensorium, is a question which perhaps physiological experiment, or even more likely pathological research, will answer before long. In the meanwhile we are exceedingly incredulous, and retain our faith in the old

opinion that consciousness resides in the cerebral convolutions, and that we are conscious of all mental changes which take place therein.

It is somewhat remarkable that, notwithstanding the large part which consciousness, or want of consciousness, plays in Dr. Carpenter's system, he has nowhere attempted to show wherein it consists or of what it is composed. Certainly it is in great part composed of the perception of sensations coming from without, and, so far, may well be located in the *sensorium commune*. The *cœnæsthesis* also, the common feeling of the organism, enters largely into its composition, and may have its place of recognition in the same cerebral centre. But evidence has yet to be sought that the consciousness of ideas, whether they be intellectual or emotional, has its seat elsewhere than in that part of the brain where these ideas are formed, namely, in the cortical layer of the cerebral convolutions. Dr. Carpenter appears to adopt the metaphysical opinion that consciousness is the perception of the *ego*, and as such is one, simple and indivisible, but the physiological view of consciousness will be that it is highly complex, and compounded variously at every varying moment of perception, ideas, and emotions, some of which obtrude more or less upon the attention, some of which are more or less faint and unrecognized, but which nevertheless exist, and can be found, if the attention be directed to them. The consciousness always is, and must be, highly complex. Even when an intense sensation seems to convert the whole body into one great pain, one sense of torture, there is that sense and the idea of it, and the emotion it causes, and some appreciation of the surroundings faintly recognized; even in *melancholia attonita*, when some one frightful delusion has taken possession of the mind to such an extent that the patient seems to have sunk into the abyss of dementia, he still hears and sees, and has some apprehension of his surroundings, so that even in this case his consciousness is the compound result of very different sensibilities. Some of these are forgotten by the memory, some are lost, but none are forgotten by the mind. As a feather falls not to the earth without drawing the earth to itself, so in psychics, the most feeble and transient sensation, unnoticed and not forgotten, because never really placed in the memory, is still a factor of the mind through all its subsequent existence, and in the history of all mind forever.

A due appreciation of the elements of consciousness, from this point of view, will perhaps lead Dr. Carpenter to admit that unrecognized and unremembered parts of consciousness have still existed among its components, and that, as no motion of matter can exist for a moment without leaving results in modifications of physical universe, so these unrecognized and unremembered parts of consciousness must serve in the chain of mental paternity or genealogy of all succeeding mental states.

The chapter on insanity is excellent, barring the intrusion of the

volitional theory. We are glad to observe, too, how fully he has adopted our own views of the *emotional* nature of insanity, and of the genesis of intellectual delusions or perverted emotions. These opinions, first advocated by us in the twelfth volume of the *Medico-Chirurgical Review*, in 1853, appear since that time to have been generally adopted by mental physicians, and it is now gratifying to obtain the concurrence of a great physiologist and philosopher.

The modes of disturbed emotion which tend to the production of insanity are not, according to our observations, the various forms of angry passion which are commonly called quick or bad temper, and the author has probably accepted, in too serious a sense, the remark made to him by Dr. Conolly on this point.

"The writer well remembers, when going with Dr. Conolly through one of the wards on the female side of the lunatic asylum at Hanwell, Dr. Conolly remarked to him, 'It is my belief that *two-thirds* of the women here have come to require restraint through the habitual indulgence of an originally bad temper'" (p. 663).

Conversational remarks of this kind are often made with little intention of their being taken accurately in support of scientific theories. Probably the doctor had just then been vexed with some extraordinary display of female temper, but we think that if questioned he would have admitted that insane women as a class have scarcely worse tempers than other women, and that angry feelings do not constitute the modes of emotion which more frequently lead to the evolution of insanity. Grief and pride, and that compound of hope and fear we call anxiety, these are the modes of emotion which are the frequent groundwork of mental disease.

In conclusion, we can strongly recommend this interesting and erudite work to our readers. If we think the automatism of the mental functions which physiologists are compelled to recognize is opposed adversely to the methods of strict science, by the much-debated and certainly unestablished doctrine of free-will, it must not be forgotten that the author, in his belief in the freedom of the will, has on his side the support of widely-spread opinion, and that it is somewhat unfortunate that his conscientious labors to prove and establish the physiological importance of free-will have fallen in this instance for review into the hands of one who, with Jonathan Edwards, believes that there is no such thing. The scope of the work is far larger than the comments which our space permits us to make would lead our readers to expect. It is replete with information, and remarkable for clearness of statement and of thought. Disagreeing, as we do, with its main purpose, we cannot avoid the expectation and the hope that it will provoke rivalry, and yet it richly deserves, and will no doubt occupy, a place in medical literature, the vacancy of which has been much felt, as a text-book on Mental Physiology.—*Journal of Mental Science.*

RECENT RESEARCHES IN PHOTOGRAPHY.

By R. MELDOLA.

A SUBSTANTIAL contribution has been recently made to our knowledge of the action of light upon silver salts—a contribution which we cannot but consider as of the highest importance to photography, both as a science and as an art.

In the autumn of last year Dr. Herman Vogel announced,[1] as the result of some experiments that he had been making, that "we are in a position to *render bromide of silver sensitive for any color we choose* —that is to say, to heighten for particular colors the sensibility it was originally endowed with." This discovery is such a decided advance that it will be interesting to trace it from the beginning. Dr. Vogel, in the first instance, found to his astonishment that some dry bromide plates, prepared by Colonel Stuart Wortley in this country, were more sensitive to the green than to the blue portions of the spectrum. This result was so totally opposed to the generally-received notions that the subject was submitted to further examination. In the next experiments, a comparison was instituted between dry bromide plates and the same plates when wet from the bath-solution of silver nitrate. The results showed a decided difference in the behavior of the plates. The sensibility of dry bromide plates appears to extend to a greater extent into the least refrangible end of the spectrum than is the case with wet plates. In Dr. Vogel's plates, which received the spectrum formed by the battery of prisms of a direct vision spectroscope from a ray of sunlight reflected from a heliostat, and passing through a slit 0.25 mm. wide, the photographic impression of the spectrum, when developed by an acid developer, extended, in the case of the dry plates, into the orange, but with wet plates not quite into the yellow. The bromide plates prepared by Vogel, moreover, did not exhibit that increased sensitiveness for the green rays which characterized Colonel Stuart Wortley's plates, and this led the German investigator to conjecture that the latter plates contained some substance which absorbed the green to a greater extent than the blue. To test this conclusion, one of the plates was washed in alcohol-and-water in order to remove the yellow coloring-matter with which the plate was coated, and it was then found to have lost, in accordance with Dr. Vogel's anticipations, its sensitiveness for the green rays. The peculiar action of the Wortley dry plates was thus shown to be due to the coating of coloring-matter, and the next step made by Vogel was to seek some substance which especially absorbed the yellow, and at the same time acted as a sensitizer by fixing the free bromine, liberated by the action

[1] *Poggendorff's Annalen*, vol. cl., p. 453.

of light, upon the silver bromide. Both these ends are fulfilled by the coal-tar color known as coralline. A plate dyed with this substance and exposed to the spectrum, exhibited two maxima of photographic action, one the ordinary maximum in the indigo (near G), and the other almost as strong in the yellow, thus affording complete confirmation of Dr. Vogel's views. Aniline green[1] was next tried. This dye is stated to absorb the red rays, and a corresponding increase of sensitiveness for the red rays was observed, the photograph again presenting two maxima of activity, the one in indigo and one in the red, coinciding in position with the absorption band of the dye. Thus, Dr. Vogel's results may be summarized by saying that a dyed film of silver bromide exhibits maxima of sensitiveness in those regions where the coloring-matter exerts its maximum of absorptive power, but the precise conditions under which these results can be obtained must be considered at present as unknown, since many observers, in repeating the experiments, among others Dr. Van Monckhoven,[2] have failed to obtain other than negative results.

In a communication made to the French Academy on the 27th of last month, however, the well-known physicist, M. Edmond Becquerel, stated that some experiments made at his instigation by M. Deshaies at the Conservatoire des Arts et Métiers had been productive of positive effects, and that some of Dr. Vogel's results with coralline and aniline green had been reproduced. M. Becquerel, however, does not confine himself to bromide films; similar results have been obtained by iodized collodion in which coralline was dissolved. A most remarkable action was observed also in the case of chlorophyll when this substance was used as a tinctorial agent. Although the collodion possessed only a faint-green color from the dissolved chlorophyll, the spectral image was of a much greater length than when plain collodion was used. Under these last circumstances the spectrum extended from the ultra-violet to between G and F, with the usual maximum of action near G, while with chlorophyll the region of strongest action extended from the ultra-violet to the line E in the green, and at the same time a weaker but yet distinct impression extended from E to beyond B in the red, with a strong band between C and D. By a close examination of the spectral image a second band of less intensity could be detected on the least refrangible side of the band between C and D, and other still weaker bands appeared in the green. The most striking confirmation of Vogel's results is to be found in the fact, observed by M. Becquerel, that the band between C and D *corresponds in position with the characteristic band of the absorption spectrum of chlorophyll dissolved in collodion.* The same results were obtained

[1] The green referred to is probably that known as "aldehyde green." The so-called "iodine green," as I have frequently observed, *transmits* a band in the red.

[2] *Photographic Journal*, No. 25, June 20, 1874.

by M. Becquerel with every plate tried and with collodions containing different quantities of chlorophyll.

It must be admitted, then, that a film exerting selective absorption in intimate contact with a sensitive film of silver bromide or iodide affects the latter in those parts of the spectrum where the selective action is taking place. Here, surely, is a wide field for investigation, and one the importance of which will be at once obvious to the physicist. Practically also, when the precise conditions of action are made known, valuable results may be anticipated from the application of this principle to science and to art. Since the year 1842, when M. Becquerel photographed the whole solar spectrum from the extreme violet to the extreme red, and when Dr. J. W. Draper photographed the violet, blue, and extreme red, no successful attempts have been made to imprint the least refrangible end of the spectrum; and this, when we consider the great importance that the study of the solar spectrum has assumed of late years, and the painful or even dangerous character of prolonged eye-observation, is to us a matter of wonder. M. Becquerel's result, it will be remembered, was obtained by a film of silver iodide, first insolated or exposed to diffused light and then to the action of the spectrum. Here, again, is another question—the precise action of *insolation* on sensitive plates—demanding explanation at the hands of the physicist. The practical aspect of Dr. Vogel's discovery need not here be discussed at length. Attention may be called to the well-known difficulty of getting reds or yellows to imprint themselves in portraiture, a difficulty which now bids fair to be overcome.

Then, again, in what we must consider as a higher sphere of practical utility, great advantage to the study of solar physics is likely to accrue. In point of fact, the photographic method of comparing spectra described in a recent communication to the Royal Society now becomes available for the whole extent of the solar spectrum, and our knowledge of the true composition of the sun will be thus in course of time recorded permanently on "that retina which never forgets."

Great results have already been achieved by photography, and greater may be looked for. It must not be forgotten that in this most interesting branch of chemical physics we are in a period either of provisional hypothesis, or, worse still, of no hypothesis at all, so that valuable additions to our knowledge of physical and chemical laws should be forthcoming. The changes wrought by a beam of light on sensitive surfaces are sometimes physical and sometimes chemical. We may appropriately recall here the fact that mechanical pressure upon a sensitized surface of a silver salt acts in the same manner as a ray of light, giving a dark stain under the action of reducing agents. The experiment of Grove also, in which an electric current is set up by the incidence of a beam of light upon a prepared Daguerreotype plate, should not be forgotten. The equivalence be-

tween light and the other form of force has not yet been established, and it may not be going too far to conjecture that thermodynamics may possibly in the future have to appeal to the action of light upon a photographic plate. In the mean time we look forward to the promised continuation of Dr. Vogel's researches with no little hope.—*Nature.*

THE ELECTRIC LIGHT FOR STEAMSHIPS.

By JOHN TROWBRIDGE,
ASSISTANT PROFESSOR OF PHYSICS AT HARVARD UNIVERSITY.

THE employment of the electric light for general purposes of illumination has not, hitherto, been successful. The difficulty of maintaining it constant, and the expense attending its use, have prevented its employment. In the old method of producing the light by a great number of cells, the chief difficulties arose in keeping the strength of the current constant, and in regulating the distance of the carbon-points between which the light was produced. Certain forms of the Daniell cell, notably that constructed by Sir William Thomson ("Jenkins's Electricity," p. 223), give a sensibly constant current for an indefinite period, if watched with great care. The solutions of the cells, however, need to be carefully removed from time to time. The distance of the carbon-points also can be regulated by various contrivances, which do the work required of them in an admirable manner. Still, chemical action cannot be looked to as an economical and constant source of the electric light.

The remarkable improvements in magneto-electric engines have led to another source of the electric light, and seem to afford a better solution of the problem of its economical use. The principle which underlies all magneto-electric engines can be briefly stated thus: The movement of an electro-magnet in the neighborhood of a stationary magnet, which may also be an electro-magnet, is sufficient to induce a current in the coil of the first electro-magnet, and this current can be exalted in strength almost indefinitely by its proper direction, and by the rapidity of the mechanical movement. The most noted engines are those of Siemen and Hulske, Wild, Ladd, and the Gramme machine. Some idea of the power of these engines can be gained from the following statement in regard to a Wild machine, of a size intended to be used for the production of the electric light for light-houses: "When worked with a power of three horses, it will consume carbon-sticks three-eighths of an inch square, and evolve a light of surpassing brilliancy. With a machine that consumes carbons half an inch square, a light of such intensity is got, that, when put on a lofty building, it casts shadows from the flames of the street-lamps a quar-

ter of a mile distant upon the neighboring walls. The same light, at two feet from the reflector, darkened ordinary sensitized photographic paper as much in twenty seconds as the direct rays of the sun at noon on a clear day in March in one minute" (Ferguson's "Electricity"). With a ten-inch quantity armature, Mr. Wild succeeded in melting an iron rod fifteen inches long and one-quarter inch thick. The entire machine by which this was accomplished was under five feet in length and height, was only twenty inches wide, and weighed a ton and a half. The Ladd engine dispenses with the use of permanent steel magnets, and is a more compact form of the machine than Wild's. The Gramme machine returns again to the use of powerful steel magnets, between the poles of which revolves a ring-shaped electro-magnet. The problem of producing the best machine for the production of electricity by mechanical power is not yet solved. The machines now before the public will doubtless be very much improved. At present, however, the means to attain the sought-for ends seem to be limited. There are not many combinations which can be made. A field of magnetic force being given, the question arises, What is the most economical means of cutting the greatest number of lines of force of the greatest intensity in the unit of time? With the most improved forms of the magneto-electric machine, we are, however, in a condition to produce an electric light of a reasonable degree of constancy and cheapness. If it is a desideratum that steamships should be provided with more powerful lights than those now in use, the electric light is the one to which attention is naturally directed. The first points to be considered are in relation to its cost, its constancy, and readiness of adjustment, and its efficiency in penetrating fogs. The light-house service of Great Britain and France affords the only experience on these points.

The electric light has been tried by Great Britain at Dungeness, and by the French Government at La Hève. The source of the light in both instances was a magneto-electric machine. A force of one and a quarter horse-power was required to drive the British machine, and one and a half the French. The descriptions of these machines show that they were extremely bulky, compared with the more improved forms, like Ladd's and the Gramme machine. The observations on the lights at La Hève are especially interesting, because they afforded a means of comparison between the fog-penetrating power of the electric light and the ordinary oil-light of light-houses. There were two light-houses at La Hève, one of which was provided with an electric light, and the other with an oil-light. The electric light was equivalent to 3,500 Carcel-burners. The oil-light had an intensity of 630 Carcel-burners.

"In foggy weather, in the hundred times of observation, the electric light was seen twice as often as the oil-light, or more. When the intensity of the electric light, compared with that of the oil-lamp

with which it was measured, is considered, this is not a favorable exhibit. An advantage, nevertheless, which the electric light very distinctly possessed over the other, was in its creating a kind of glow in the fog, by which mariners were enabled to recognize the position of the capes even when both lights were invisible. Experiments were made with the view of ascertaining, with some approach to accuracy, the relative fog-penetrating power of the two descriptions of light produced by electricity and by ordinary combustion, when the photometric intensities are equal; and also the excess of intensity which must be given to the former light, in order that its power in this respect may be equal to that of a lamp fed by oil. In these experiments it was attempted to imitate, as nearly as possible, the absorbent effect of fogs, by interposing glasses of different colors—red, orange, yellow, etc.—before each of the lights successively. The conclusion which these experiments seem to justify is, that, whenever an electric light exceeds in intensity a light produced by a lamp two and a half times, it will penetrate, at least as well as the latter, the fogs most unfavorable to the transmission of the rays. And, as a fact, in whatever state of the weather, the electric light at La Hève has always had the largest range of visibility" ("Reports of the United States Commissioners to the Paris Exposition, 1867," vol. iii.).

M. Becquerel, in an article on electrical apparatus exhibited in the Exposition of 1862, enters into a calculation of the cost of the electric light, compared with other methods of illumination. His estimates are based upon a light produced by a magneto-electric engine, driven by an engine of two horse-power, which light he calculated was equivalent to that produced by 700 stearine-candles. He compares the light thus obtained with that obtained of equal intensity from the galvanic battery—from coal-gas, oil of colza, tallow, stearine, and wax. "The price of gas taken was $\frac{30}{100}$ of a franc per cubic metre—equivalent to 17 cents per 100 cubic feet; oil of colza, $1.28 per gallon; tallow, in the form of candles, 16 cents; stearine, 36 cents; and wax, 52 cents per pound." The cost of the electric light he assumes to be only that of the combustibles required to run the engine. From these data he deduces the following values:

A light equal to that of 700 stearine-candles will cost per hour:

1	produced by the		Machine	2 to 4 cents.
2	"	"	Galvanic battery	38 to 94 cents.
3	"	"	Coal-gas	62 cents.
4	"	"	Kerosene	73 cents.
5	"	"	Pure oil of Colza	$1.14
6	"	"	Tallow-candles	2.37
7	"	"	Stearine	5.00
8	"	"	Wax	6.10

"In point of cheapness there would seem to be no comparison between the electric light and that produced by even the least costly of

the materials ordinarily employed for purposes of illumination. Actual experiment, however, in the use of these machines in French light-houses, has shown that these figures require important modifications" ("United States Commissioner's Report to the Paris Exposition, 1867," vol. iii., p. 421).

The French Commission, in view of the experience gained by the establishment of the light at La Hève, did not advocate the extension of the use of the electric light to light-house illumination in general. The expense of maintaining the electric light at Dungeness, irrespective of the original cost, was estimated to be £758 18*s.* 9*d.* per annum. M. Becquerel evidently did not take into account in his calculation the original cost of the machine; and the expense of the light at Dungeness would be modified by the greater cheapness of the more improved forms of engines.

For several years it has been rumored that various steamships were to be furnished with the electric light instead of the old well-established masthead-light. No trial has yet been made. The cost of the apparatus, together with the imperfect means hitherto devised for maintaining the light constant, has deterred, apparently, the owners of steamship lines from making a change in this direction. When we reflect that the best masthead-light now in use can be seen only from four to five miles—by some authorities stated from three to four—and in a fog at night is practically not visible more than the length of a steamship ahead, it is not surprising that the general public look earnestly for a change for the better. The experience which the use of the electric light in light-houses has given us is, on the whole, favorable to an extension of the use of the light to steamships. There is no question of the superiority of the electric light over other powerful lights available for steamships, when the great intensity of the light and the compactness of the necessary apparatus are considered. The following is an estimate of the probable cost of fitting steamships with an electric light, together with its maintenance:

FIRST COST.

Machine	$1,500
Regulators and attachments	300
Small engine to run the machine	600
Total	$2,400

MAINTENANCE.

Interest on capital, at ten per cent	$240
Salary of electrical engineer	600
Carbons (or other incandescent material), repairs, etc	300
Total	$1,140

Suppose that the vessel made 18 trips during the year, of 12 days each (216 days), suppose that the electric light was used 10 hours each night (2,160 hours), giving about 53 cents as the cost per hour,

the additional fuel required, estimated at three cents per hour, would bring the estimate up to 56 cents per hour. It is probable that a suitable magneto-electric engine would cost less than our estimate. The engine of Mr. M. G. Farmer, of Boston, the celebrated electrician, bids fair to play an important part in applications of the electric light. The engines of the ship could doubtless run by suitable attachments the magneto-electric engine, and our estimate of one attendant would doubtless prove sufficient, with the aid of the ordinary ship-watch.

When one reflects upon the number of steamships crossing the Atlantic, and the increasing danger of collision, with the feeble lights now in use, one is forced to wonder at the want of agitation of the subject. It is safe to affirm that, had the Ville du Havre been provided with more powerful lights, the fatal collision would not have happened. The loss which the steamship company suffered by this collision would have furnished their entire fleet with the apparatus for producing the electric light. With a careful watch, a light which can be seen three miles on a clear night would doubtless prove sufficient. The fog-whistle, with an equally careful watch, can also be made efficient to prevent collisions. But a careful watch cannot always be had; there are many temptations to be careless. Drowsiness, in chilly weather, creeps upon even a conscientious lookout, and a powerful masthead-light would supplement human fallibility.

ARE ANIMALS AUTOMATONS?[1]

By Prof. T. H. HUXLEY, LL. D., F. R. S.

I SHALL go no further back than the seventeenth century, and the observations which I shall have to offer you will be confined almost entirely to the biological science of the time between the middle of the seventeenth and middle of the eighteenth centuries. I propose to show what great ideas in biological science took their origin at that time, in what manner the speculations then originated have been developed, and in what relation they stand to what is now understood to be the body of scientific biological truth. The middle of the seventeenth century is one of the great epochs of biological science. It was at that time that an idea arose that vital phenomena, like all other phenomena of the physical world, are capable of mechanical explanation, that they are reducible to law and order, and that the study of biology is an application of the great science of physics and chemistry. Harvey was the first clearly to explain the mechanism of the

[1] An address delivered before the British Association at Belfast, August 25th.

circulation of the blood, and by that remarkable discovery of his he laid the foundation of a scientific theory of the larger part of the processes of living beings—those processes, in fact, which we now call processes of sustentation—and by his studies of development he first laid the foundation of a scientific knowledge of reproduction. But, besides these great powers of living beings, there remains another class of functions—those of the nervous system—with which Harvey did not grapple. It was, indeed, left for a contemporary of his, Réné Descartes, to play a part in relation to the phenomena of the nervous system which is precisely equal in value to that Harvey played in regard to the circulation. You must recollect that this man Descartes was not merely, as some had been, a happy speculator. He was a working anatomist and physiologist, conversant with all the anatomical and physiological law of his time. A most characteristic anecdote of him, and one which should ever put to silence those shallow talkers who speak of Descartes as an hypothetical and speculative philosopher, is, that a friend once calling upon him in Holland begged to be shown his library. Descartes led him into a sort of shed, and, drawing aside a curtain, displayed a dissecting-room full of the bodies of animals in course of dissection, and said, "There is my library."

The matters of which we shall treat are such as to require no extensive knowledge of anatomy. I need only premise that what we call the nervous system in one of the higher animals consists of a central apparatus, composed of the brain, which is lodged in the skull, and of a cord proceeding from it, which is termed the spinal marrow, and which is lodged in the vertebral column or spine, and that then from these soft white masses—for such they are—there proceed cords which are termed nerves, some of which nerves end in the muscle, while others end in the organs of sensation. The first proposition that you find definitely and clearly stated by Descartes is the view that the brain is the organ of sensation, of thought, and of emotion—using the word "organ" in this sense, that certain changes which take place in the matter of the brain are the essential antecedents of those states of consciousness which we term sensation, thought, and emotion. If your friend disagrees with your opinion, runs amuck against any of your pet prejudices, you say, "Ah! poor fellow, he is a little touched here," by which you mean that his brain is not doing its business properly—that he is not thinking properly—thereby implying that his brain is some way affected. It remained down to the time of Bichat a question whether the passions were or were not located in the abdominal viscera. In the second place, Descartes lays down the proposition that all the movements of the animal bodies are effected by the change of form of a certain part of the matter of their bodies, to which he applies the general term of muscle. That is a proposition which is now placed beyond all doubt whatever. If I move my arm, that movement is due to the change of this mass in

front called the biceps muscle; it is shortened till it becomes thicker. If I move any of my limbs, the reason is the same. As I now speak to you, the different tones of my voice are due to the exquisitely accurate adjustments and adjusted contractions of a multitude of such particles of flesh; and there is no considerable and visible movement of the animal body which is not, as Descartes says, resolvable into these changes in the form of matter termed muscle. But Descartes went further, and he stated that in the normal and ordinary condition of things these changes in the form of muscle in the living body only occur under certain conditions; and the essential condition of the change was, says Descartes, the motion of the matter contained within the nerves, which go from the central apparatus to the muscle. Descartes gave this moving material a particular name—the animal spirits. Nowadays we should not say that the animal spirits existed, but we should say that a molecular change takes place in the nerve, and that that molecular change is propagated at a certain velocity which has been measured from the central apparatus to the muscle. Modern physiology has measured the rate of the change to which I have referred.

Next, Descartes says that, under ordinary circumstances, this change in the contents of a nerve, which gives rise to the contraction of a muscle, is produced by a change in the central nervous apparatus, as, for example, the brain. We say at the present time exactly the same thing. Descartes said that the animal spirits were stored up in the brain, and flowed out from the motor nerve. We say that a molecular change takes place in the brain that is propagated along the motor nerve. Further, Descartes stated that the sensory organs which give rise to our feelings gave rise to a change in the sensory nerves, to a flow of animal spirits along those nerves, which flow was propagated to the brain. If I look at this candle before us, the light falling on the retina of my eye gives rise to an affection of the optic nerve, which affection Descartes described as a flow of the animal spirits to the brain; but the fundamental idea is the same. In all our notions of the operations of nerve we are building upon Descartes's foundation. He says that, when a body which is competent to produce a sensation touches the sensory organs, what happens is the production of a mode of motion of the sensory nerves. That mode of motion is propagated to the brain. That which takes place in the brain is still nothing but a mode of motion. But, in addition to this mode of motion, there is, as everybody can find by experiment for himself, something else which can in no way be compared to motion, which is utterly unlike it, and which is that state of consciousness which we call a sensation. Descartes insists over and over again upon this total disparity between the agent which excites the state of consciousness and the state of consciousness itself. He tells us that our sensations are not pictures of external things, but that they are symbols or signs of them; and in doing that he made one of the greatest possible revolutions, not only

in physiology but in philosophy. Till his time it was the notion that visible bodies, for example, gave from themselves a kind of film which entered the eye and so went to the brain, *species intellectuales* as they were called, and thus the mind received an actual copy or picture of things which were given off from it. In laying down that proposition upon what I imagine to be a perfectly irrefragable basis, Descartes laid the foundation of that form of philosophy which is termed idealism, which was subsequently expanded to its uttermost by Berkeley, and has taken all sorts of shapes since.

But Descartes noticed not only that under certain conditions an impulse made by the sensory organ may give rise to a sensation, but that under certain other conditions it may give rise to motion, and that this motion may be effected without sensation, and not only without volition, but even contrary to it. I know in no modern treatise of a more clear and precise statement than this of what we understand by the automatic action of the brain. And what is very remarkable is, that, in speaking of these movements which arise by a sensation being as it were reflected from the central apparatus into a limb—as, for example, when one's finger is pricked and the arm is suddenly drawn up, the motion of the sensory nerve travels to the spine and is again reflected down to the muscles of the arm—Descartes uses the very phrase that, we at this present time employ. And the last great service to the physiology of the nervous system which I have to mention as rendered by Descartes was this, that he first, so far as I know, sketched out the physical theory of memory. What he tells you in substance is this, that when a sensation takes place, the animal spirits travel up the sensory nerve, pass to the appropriate part of the brain, and there, as it were, find their way through the pores of the substance of the brain. And he says that, when the particles of the brain have themselves been shoved aside a little by the single passage of the animal spirits, the passage is made easier in the same direction for any subsequent flow of animal spirits, and that the repetition of this action makes it easier still, until at length it becomes very easy for the animal spirits to move these particular particles of the brain, the motion of which gives rise to the appropriate sensation, until at length the passage is so easy that almost any thing, especially an associated flow which may be set going, allows the animal spirits to flow into these already open pores more easily than they would flow in any other direction; and in this way a flow of the animal spirits recalls the image—the impression made by a former sensory act. That, again, is essentially in substance at one with all our present physical theories of memory. In one respect Descartes proceeded further than any of his contemporaries, and has been followed by very few of his successors in later days. Descartes reasoned thus: "I can account for many such actions, many reflex actions taking place without the intervention of consciousness, and even in opposition to the will." So far

these occur, as, for example, when a man in falling mechanically puts out his hands to save himself. "In these cases," Descartes said, "I have clear evidence that the nervous system acts mechanically without the intervention of consciousness, and without the intervention of the will, it may be in opposition to it." Why, then, may I not extend this idea further? As actions of a certain amount of complexity are brought about in this way, why may not actions of still greater complexity be so produced? Why, in fact, may it not be that the whole of man's physical actions are mechanical, his mind living apart, like one of the gods of Epicurus, but unlike them occasionally, interfering by means of his volition?

And it so happened that Descartes was led by some of his speculations to believe that beasts had no soul, and consequently, according to his notion, could have no true mental operations, and no consciousness; and thus, his two ideas harmonizing together, he developed that famous hypothesis of the automatism of brutes, which is the main subject of my present discourse. What Descartes meant by this was that animals are absolutely machines, as if they were mills or barrel-organs; that they have no feelings; that a dog does not hear, and does not smell, but that the impression which thus gave rise to those states of consciousness in the dog gave rise by a mechanical reflex process, to actions which correspond to those which we perform when we do smell, and do taste, and do see. Suppose an experiment. Suppose that all that is taken away of the brain of a frog is what we call the hemisphere, the most anterior part of the brain. If that operation is properly performed, very quickly and very skillfully, the frog may be kept in a state of full bodily vigor for months, or it may be for years; but it will sit forever in the same spot. It sees nothing; it hears nothing. It will starve sooner than feed itself, although, if food is put into its mouth, it swallows it. On irritation, it jumps or walks; if thrown into the water, it swims. But the most remarkable thing that it does is this —you put it in the flat of your hand, it sits there, crouched, perfectly quiet, and would sit there forever. Then if you incline your hand, doing it very gently and slowly, so that the frog would naturally tend to slip off, you feel the creature's fore-paws getting a little slowly on to the edge of your hand until he can just hold himself there, so that he does not fall; then, if you turn your hand, he mounts up with great care and deliberation, putting one leg in front and then another, until he balances himself with perfect precision upon the edge of your hand; then if you turn your hand over he goes through the opposite set of operations until he comes to sit in perfect security upon the back of your hand. The doing of all this requires a delicacy of coördination and an adjustment of the muscular apparatus of the body which are only comparable to those of a rope-dancer among ourselves; in truth, a frog is an animal very poorly constructed for rope-dancing, and on the whole we may give him rather more credit than we should to a human dancer.

These movements are performed with the utmost steadiness and precision, and you may vary the position of your hand, and the frog, so long as you are reasonably slow in your movements, will work backward and forward like a clock. And what is still more remarkable is this, that, if you put him on a table, and put a book between him and the light, and give him a little jog behind, he will jump—take a long jump, very possibly—but he won't jump against the book; he will jump to the right or to the left, but he will get out of the way, showing that, although he is absolutely insensible to ordinary impressions of light, there is still a something which passes through the sensory nerve, acts upon the machinery of his nervous system, and causes it to adapt itself to the proper action.

I need not say that since those days of commencing anatomical science when criminals were handed over to the doctors, we cannot make experiments on human beings, but sometimes they are made for us, and made in a very remarkable manner. That operation called war is a great series of physiological experiments, and sometimes it happens that these physiological experiments bear very remarkable fruit. A French soldier, a sergeant, was wounded at the battle of Bareilles. The man was shot in what we call the left parietal bone. The bullet, I presume, glanced off, but it fractured the bone. He had enough vigor left to send his bayonet through the Prussian that shot him. Then he wandered a few hundred yards out of the village, where he was picked up and taken to the hospital, where he remained some time. When he came to himself, as usual in such cases of injury, he was paralyzed on the opposite side of the body, that is to say, the right arm and the right leg were completely paralyzed. That state of things lasted, I think, the better part of two years, but sooner or later he recovered from it, and now he is able to walk about with activity, and only by careful measurement can any difference between the two sides of his body be ascertained. At present this man lives two lives, a normal life and an abnormal life. In his normal life he is perfectly well, cheerful, and a capital hospital attendant, does all his work well, and is a respectable, well-conducted man. That normal life lasts for about seven-and-twenty days, or thereabouts, out of every month; but for a day or two in each month—generally at intervals of about that time—he passes into another life, suddenly, and without warning or intimation. In this life he is still active, goes about just as usual, and is to all appearance just the same man as before; goes to bed and undresses himself, gets up, makes his cigarette and smokes it, and eats and drinks. But in this condition he neither sees, nor hears, nor tastes, nor smells, nor is he conscious of any thing whatever, and has only one sense-organ in a state of activity—viz., that of touch, which is exceedingly delicate. If you put an obstacle in his way he knocks against it, feels it, and goes to the one side. If you push him in any direction he goes straight on, illustrating, as well as he can, the first law of motion. You see I have

said he makes his cigarettes, but you may make his tobacco of shavings or of any thing else you like, and still he will go on making his cigarettes as usual. His action is purely mechanical. As I said, he feeds voraciously, but whether you give him aloes or asafœtida, or the nicest thing possible, it is all the same to him.

The man is in a condition absolutely parallel to that of the frog, and no doubt, when he is in this condition, the functions of his cerebral hemispheres are at any rate largely annihilated. He is very nearly —I don't say wholly, but very nearly—in the condition of an animal in which the cerebral hemispheres are not entirely extirpated, but very largely damaged. And his state is wonderfully interesting to me, for it bears on the phenomena of mesmerism, of which I saw a good deal when I was a young man. In this state he is capable of performing all sorts of actions on mere suggestion—as, for example, he dropped his cane, and a person near him put it into his hand, and the feeling of the end of the cane evidently produced in him those molecular changes of the brain which, had he possessed consciousness, would have given rise to the idea of his rifle; for he threw himself on his face, began feeling about for his cartouche, went through the motions of touching his gun, and shouted out to an imaginary comrade, "Here they are, a score of them; but we will give a good account of them." This paper to which I refer is full of the most remarkable examples of this kind, and what is the most remarkable fact of all is, the modifications which this injury has made in the man's moral nature. In his normal life he is one of the most upright and honest of men. In his abnormal state, however, he is an inveterate thief. He will steal every thing he can lay his hands upon, and, if he cannot steal any thing else, he will steal his own things and hide them away. Now, if Descartes had had this fact before him, need I tell you that his theory of animal automatism would have been enormously strengthened? He would have said: "Here, I show you a case of a man performing actions evidently more complicated and mostly more rational than any of the ordinary operations of animals; and yet you have positive proof that these actions are merely mechanical. What, then, have you to urge against my doctrine that the whole animal world is in that condition, and that—to use the very correct words of Father Malebranche—'Thus in dogs, cats, and other animals, there is neither intelligence nor spiritual soul as we understand the matter commonly; they eat without pleasure—they cry without pain—they grow without knowing it—they desire nothing, they know nothing; and, if they act with dexterity and in a manner which indicates intelligence, it is because God, having made them with the intention of preserving them, has constructed their bodies in such a manner that they escape organically, without knowing it, every thing which could injure them, and which they seemed to fear.'"

But I must say for myself—looking at the matter on the ground

of analogy—taking into account that great doctrine of continuity which forbids one to suppose that any natural phenomenon can come into existence suddenly and without some precedent, gradual modification tending toward it—taking that great doctrine into account (and every thing we know of science tends to confirm it), and taking into account on the other hand the incontrovertible fact that the lower animals which possess brains at all possess, at any rate, in rudiments a part of the brain, which we have every reason to believe is the organ of consciousness in ourselves, then it seems vastly more probable that the lower animals, although they may not possess that sort of consciousness which we have ourselves, yet have it in a form proportional to the comparative development of the organ of that consciousness, and foreshadow more or less dimly those feelings which we possess ourselves. I think that is, probably, the most rational conclusion that can be come to. It has this advantage, that it relieves us of the very terrible consequences of making any mistake on this subject. I must confess that, looking at that terrible struggle for existence which is everywhere going on in the animal world, and considering the frightful quantity of pain which must be given and received in every part of the animal world, I say that is a consideration which would induce me wholly to adopt the view of Descartes. Yet I think it on the whole much better to err on the right side, and not to concur with Descartes on this point. But let me point out to you that, although we may come to the conclusion that Descartes was wrong in supposing that animals are insensible machines, it does not in the slightest degree follow that they are not sensitive and conscious automata; in fact, that is the view which is more or less clearly in the minds of every one of us. When we talk of the lower animals being provided with instinct, and not with reason, what we really mean is that, although they are sensitive, and, although they are conscious, yet they do act mechanically, and that their different states of consciousness, their sensations, their thoughts (if they have them), their volitions (if they have them), are the products and consequences of the mechanical arrangements. I must confess that this popular view is to my mind the only one which can be scientifically adopted. We are bound by every thing we know of the operations of the nervous system to believe that, when a certain molecular change is brought about in the central part of the nervous system, that change, in some way utterly unknown to us, causes that state of consciousness that we term a sensation. It is not to be doubted that the impression excited by those motions which give rise to sensation leaves in the brain molecular changes which answer to what Haller called "*vestigia rerum*," and which that great thinker David Hartley termed "vibratiuncles," which we might term sensigenous molecular, and which constitute the physical foundation of memory. Those same changes gave rise naturally to conditions of pleasure and pain, and to those emotions which in ourselves we call

volition. I have no doubt that is the relation between the physical processes of the animal and his mental processes. In each case it follows inevitably that these states of consciousness can have no sort of relation of causation to the motions of the muscles of the body. The volition of animals will be simply states of emotion which precede their actions. The only conclusion, then, at which there seems any good ground for arriving is, that animals are machines, but that they are conscious machines.

I might, with propriety, consider what I have now said, as the conclusion of the observations which I have to offer concerning animal automatism. So far as I know, the problem which we have hitherto been discussing is an entirely open one. I do not know that there is any reason on the part of any person, whatever his opinions may be, that can prevent him, if he be so inclined, from accepting the doctrine which I have just now put before you. So far as we know, animals are conscious automata. That doctrine is perfectly consistent with any view we may choose to take on a very curious subject of speculation—whether animals possess souls or not, and whether, if they possess souls, those souls are immortal or not. The doctrine to which I have referred is not inconsistent with the perfectly strict and literal adherence to the Scripture text concerning the beast that perisheth, nor, on the other hand, so far as I know, does it prevent any one from entertaining the amiable convictions ascribed by Pope to his untutored savage, that, when he passed to the realms of the blessed, his faithful dog should bear him company. In fact, all these accessory questions to which I have referred involve problems which cannot be discussed by physical science as such, as they lie, not within the scope of physical science, but come within the scope of that great mother of all science, Philosophy. Before any direct answer can be given upon any of these questions, we must hear what Philosophy has to say for and against the views that may be held. I have now laid these facts before you. I do not doubt that that fate will befall me which has befallen better men, and I shall have to bear in patience the reiterated assertion that doctrines such as I have put before you have very evil tendencies. I should not wonder if you were told that my intention in bringing this subject before you is to lead you to apply the doctrine I have stated to man as well as brutes, and it will then certainly be further stated that the logical tendency of such a doctrine is Fatalism, Materialism, and Atheism.

Now, let me ask you to listen to another product of that long experience to which I have referred. The logical consequences are very important; but in the course of my experience I have found that they were the scarecrows of fools and the beacons of wise men. Logical consequences can take care of themselves. The only question for any man to ask is this: "Is this true or is it false?" No other question can possibly be taken into consideration until that one is settled. Un-

doubtedly I do hold that the view I have taken of the relations between the physical and mental faculties of brutes applies in its fullness and entirety to man; and, if it was true that the logical consequences of that belief must land me in all these terrible things, I do not hesitate in allowing myself to be so landed. I should conceive that, if I refused, I should have done the greatest and most abominable violence to every thing which is deepest in my moral nature. But now I beg leave to say that, in my conviction, there is no such logical connection as is pretended between the doctrine I accept and the consequences which people profess to draw from it. Many years ago I had occasion, in dealing with the philosophy of Descartes, and some other matters, to state my conviction pretty fully on those subjects, and, although I know by experience how futile it is to endeavor to escape from those nicknames which many people mistake for argument, yet, if those who care to investigate these matters in a spirit of candor and justice will look into those writings of mine, they will see my reasons for not imagining that such conclusions can be drawn from such premises. To those who do not look into these matters with candor and with a desire to know the truth I have nothing whatever to say, except to warn them on their own behalf what they do; for assuredly, if, for preaching such doctrine as I have preached to you to-night, I am cited before the bar of public opinion, I shall not stand there alone. On my one hand I shall have, among theologians, St. Augustine, John Calvin, and a man whose name should be well known to the Presbyterians of Ulster—Jonathan Edwards—unless, indeed, it be the fashion to neglect the study of the great masters of divinity, as many other great studies are neglected nowadays. I should have upon my other hand, among the philosophers, Leibnitz; I should have Père Malebranche, who saw all things in God; I should have David Hartley, the theologian as well as philosopher; I should have Charles Bonnet, the eminent naturalist, and one of the most zealous defenders Christianity has ever had. I think I should have, within easy reach at any rate, John Locke. Certainly the school of Descartes would be there, if not their master; and I am inclined to think, in due justice, a citation would have to be served upon Emmanuel Kant himself. In such society it may be better to be a prisoner than a judge; but I would ask those who are likely to be influenced by the din and clamor which are raised about these questions whether they are more likely to be right in assuming that those great men I have mentioned—the fathers of the Church and the fathers of philosophy—knew what they were about, or that the pigmies who raise this din know better than they did what they meant. It is not necessary for any man to occupy himself with problems of this kind unless he so choose. Life is full enough, filled amply to the brim, by the performance of its ordinary duties; but let me warn you, let me beg you to believe that if a man elect to give a judgment upon these great questions; still more, if he

assume to himself the responsibility of attaching praise or blame to his fellow-men for the judgments which they may venture to express, I say that, unless he would commit a sin more grievous than most of the breaches of the Decalogue, let him avoid a lazy reliance upon the information that is gathered by prejudice and filtered through passion. Let him go to these great sources that are open to him as to every one, and to no man more open than to an Englishman; let him go back to the facts of Nature, and to the thoughts of those wise men who for generations past have been the interpreters of Nature.

TYNDALL'S RELATION TO POPULAR SCIENCE.

By Professor HELMHOLTZ.[1]

THE awakening desire for scientific instruction, ever finding new expression among the educated classes of all European countries, we must consider not merely as a striving after new forms of amusement, or a mere empty and barren curiosity; it is rather a well-justified intellectual necessity, and is in close connection with the most important springs of mental development in these times. The natural sciences have become a powerful influence in the formation of the social, industrial, and political life of civilized nations, not only from the fact that the great forces of Nature have been subordinated to the aims of man, and have supplied him with a host of new means to attain them; though this mode of their action is sufficiently important that the statesman, the historian, and the philosopher, as well as the manufacturer and the merchant, cannot pass without participation in, at least, the practical results; but because there is another form of their action which goes much deeper and further, though it is, perhaps, more slow in manifesting itself; I mean their influence in the direction of the intellectual progress of humanity. It has often been said, and even brought as a charge against the natural sciences, that, through them, a schism (*Zwiespalt*), formerly unknown, has been introduced into modern education. And, indeed, there is truth in this. A schism *is* perceptible; yet such must mark every new step of intellectual development wherever the New has become a power, and the question to be settled is, the definition of its just claims, as against the just claims of the Old. The past progress of education of civilized nations has had its central point in the study of language. Language is the great instrument through possession of which man is most distinctly separated from the lower animals; through use of which he is

[1] From the preface to the recently-published German translation of Tyndall's "Fragments of Science," revised by the writer, Prof. Helmholtz, for *Nature*.

able to share the experience and knowledge of other individuals of his time, as also those of past generations; without which each man would, like the lower animals, be limited to his instinct and to his own particular experience. That therefore the improvement of language was formerly the first and most necessary work of a growing race, and that the most refined perfection of its comprehension and its use is, and must ever be, the primary problem in the education of each individual, is undoubted. The culture of modern European nations has a peculiarly intimate connection with the study of the remains of antiquity; and, thereby, directly with the study of language. With the latter study was associated that of the forms of thought, which are coined in speech; logic and grammar, that is, according to the original meaning of the words, the art of speaking and the art of writing, both taken in the highest sense, have therefore been hitherto the natural hinge-points of mental education.

But while language is the means of handing down and preserving truth once recognized, we must not forget that its study teaches nothing as to how fresh truth is to be found. Similarly, logic shows how, from the proposition which forms the major of a syllogism, conclusions are to be drawn; but it can tell us nothing as to whence this proposition has come. He who will convince himself of its independent truth must, on the other hand, begin with knowledge of the individual cases which fall under the law, and which afterward, if this have been established, may doubtless also be accepted as deductions from the law. But only where a knowledge of the law is one which has been communicated by others, does it actually take precedence of knowledge of the deductions, and, in such a case, the treatises of the old formal logic assume their undeniable practical importance.

Thus all these studies do not themselves lead us to the proper source of knowledge—do not bring us face to face with the reality which we seek to know. There is therefore, undoubtedly, a danger in communicating to each one, by preference, a knowledge the source of which he has not personally contemplated. Comparative mythology and the criticism of the metaphysical systems can tell a great deal of how figurative word-expression has in time been exalted to the importance of real knowledge, and even become valued as ultimate wisdom.

While fully recognizing, then, the significance (not to be sufficiently appreciated) of the finely-elaborated art of communicating the acquired knowledge of others, and receiving in return such communications from others, in regard to the mental improvement of our race; while also recognizing the importance attaching to the contents of the classical writings, for the cultivation of the moral and æsthetic sentiments, for the development of an intimate knowledge of human feelings, conceptions, and conditions of culture; we must yet hold that an important element is wanting from the exclusively literary-logical

mode of education; and that is the methodical discipline of the activity by which we reduce the confused material which meets us in the actual world, apparently (at first sight) ruled by wild chance rather than reason, to clear conception, and thereby make it fit for expression in speech. Such an art of observation and experiment, methodically developed, we have hitherto found in the natural sciences alone; and our hope, that the psychology of individuals and peoples, with the practical sciences of education and of social and political government based upon it, will attain the same end, can only be fulfilled in a distant future.

This new enterprise, prosecuted by natural science on new paths, has quickly enough yielded fresh and, of their kind, unheard-of results, evidencing what achievements human thought is capable of, where it can go the whole way from the facts to the full knowledge of the law under favorable conditions, testing and knowing every thing for itself. The simple relations, especially those of inorganic Nature, permit of our possessing such a penetrating and accurate knowledge of their laws, such far-reaching deduction of inferences from them, and the testing and verification of these by such an exact reference to fact, that, with the systematic unfolding of such conceptions (e. g., with the deduction of astronomical phenomena from the law of gravitation), there is hardly any other edifice of human thought which, for strict logic, certainty, correctness, and productiveness, can at all be compared with it.

I point out these relations merely with the view of showing in what sense the natural sciences are a new and essential element of human education; of indestructible importance, also, for all further development of this in the future; and that a complete education of the individual man, as of nations, will no longer be possible without a union of the past literary-logical with the new natural-science direction of study.

Now, the majority of the educated hitherto have been instructed only in the old way—have hardly at all come into contact with the work of thought in natural science; at the most, perhaps, a little with mathematics. It is men of this kind of education that our governments appoint, by preference, to educate our children, to maintain reverence for moral order, and to preserve the treasures of knowledge and wisdom of our forefathers. It is they, too, who must organize the changes in the mode of education of the rising generation; where such changes are required they must be encouraged or compelled thereto by the public opinion of the intelligent classes of the whole community, both men and women.

Apart from the natural impulse of every warm-hearted man to lead others to that which he has found to be true and right, there will be in every friend of natural science a strong motive to share in such work, in the reflection that the further development of these sciences

themselves, the unfolding of their influence on human education, and, so far as they are a necessary element of this education, the healthiness of the future mental development of the people, depend on an insight being afforded to the educated classes, into the nature and the results of scientific investigation, such as is generally possible, without a personal engrossing occupation with these subjects.

And in proof that the need of such an insight is felt even by those who have grown up under the predominant linguistic and literary instruction, may be cited the large number of popular books of natural science annually published, and the eagerness with which lectures of a popular character on subjects in natural science are attended.

It lies in the nature of the case, however, that the essential part of this want, owing to the depth of its roots, is not easily satisfied. It is true that what science may have established and wrought out in solid results can, by intelligent compilers, be put together and brought into suitable form, so that a reader without previous knowledge of the subject may, with some perseverance and patience, understand it. But such a knowledge, limited to the actual results, is not properly that which we have in view. These books, indeed, compiled with the best intentions, often lead into devious paths. To prevent weariness, they must seek to rivet the attention of the reader by an accumulation of curiosities, whereby the image of science is rendered quite false. One often feels this when the reader begins from his own impulse to tell what he has considered important. Then there are the further objections that the book can give only word-descriptions, or, at the most, drawings representing more or less imperfectly the things and processes of which it treats; and that the reader's power of imagination is thereby subjected to a much greater strain, with much less satisfactory results, than that of the investigator or student who, in museum collections and laboratories, sees the things before him in their living reality. A portion of the difficulties named may readily be obviated in popular lectures, if, at least, some objects or experiments can be shown: the opportunities of doing so in Germany, hitherto, have been mostly very limited.

It appears to me, however, that it is not so much a knowledge of results of scientific investigations in themselves that the most intelligent and well-educated of the laity ask, but rather a perception of the mental activity of the investigator, of the individuality of his scientific procedure, of the aims at which he strives, of the fresh point of view which his work affords in reference to the great problems of human existence. There can hardly be any thing of all this in the properly scientific treatment of scientific objects; on the contrary, the severe discipline of the exact method requires that, in scientific treatises, only that be spoken of which is surely ascertained, hypotheses only where equivalent to the proposal of questions for further investigation, a certain answer to these appearing probable from the next

progress of the research. A natural prudence recommends great rigor in this connection. For it is pretty much the same to the greater number even of the instructed hearers whether a man of science says "I know," or "I suppose;" they only ask after the result and the authority by which it is supported, not the grounds or the doubts. It is thus not to be wondered at if earnest investigators do not willingly shock the confidence of their readers in what the former may think true and demonstrable, by the enumeration of ideas of the correctness of which they do not feel themselves quite secure. These may be very probable, and may be expressed with ever so much prudence and careful guardedness; they still expose him who utters them to the danger of vexatious misrepresentation.

It is, further, not to be overlooked, that the peculiar discipline of scientific thought which is necessary for the most abstract and rigorous grasp possible of newly-found ideas and laws, and for the purification from all accidents of the sensuous order of phenomena, along with the habitual residence of the mind among a circle of ideas far removed from general interest, is not a quite favorable preparative for a popular intelligible exposition of the insights obtained, to hearers who have not had the like discipline. For this task there is rather required an artistic talent of exposition, a certain kind of eloquence. The lecturer or writer must find generally accessible stand-points from which he may call forth new representations with the most vivid distinctness, and then allow the abstract principle, which he seeks to make intelligible, to derive from these concrete life. This is almost an opposite mode of treatment to that which obtains in scientific treatises, and it can readily be understood that the men are rare who are equally fitted for both these kinds of intellectual labor.

Owing to all these circumstances, a sort of dividing wall is raised between the men of science and the laity who might obtain instruction and guidance from them. That many, and indeed some of the most able, investigators have the qualities and peculiarities belonging to abstract work is natural, and will, in each individual case, be at once willingly excused. I have here merely to guard against the reversal of this relation, as if the defects named were necessary, or at all constituted a prerogative.

The compilers can give no help in those directions where the original thinkers have neglected or avoided expressing themselves. So much the more gratifying is it, I consider, in such a state of things, when, among those who have shown the highest ability for original scientific work, there is found, at times, a man like Tyndall, full of enthusiasm for the problem of making the newly-acquired insights and outlooks of his science available for the wider circle of the people, and, at the same time, endowed with other qualities which are the necessary conditions of success toward this end, eloquence and the gift of lucid exposition.

In England the custom of popular scientific lectures has been much longer in existence than in Germany. Since the constitution of the English universities is very different from ours, fewer individuals are there in a position to prosecute scientific research, or give scientific instruction to regularly prepared scholars, as their life-calling. This generally makes it much more difficult for individuals to go deeply into a special department of study, though genius of course everywhere breaks through these and other hindrances. The same circumstance has, on the other hand, maintained a closer connection of the workers in science with all other classes of the population, and incited to a more liberal care for the instruction of the student not regularly trained. While this has hitherto been quite rare in Germany, there have long been in England solid and well-furnished institutions for the purpose.

In the two circumstances, first that in England courses of a moderate number of connected lectures can be delivered, and secondly that this can be done in buildings well suited for demonstrations and experiments of every kind, there is a great advantage over the general custom in Germany, where each lecturer only delivers one lecture.

Now, it is intelligible that during the seventy years since this state of things has arisen, and under so much more favorable external conditions, the English public have educated their lecturers, and the lecturers their public, much better than has hitherto been the case in Germany. The Royal Institution has had, among its professors, two men of the first rank, Sir Humphrey Davy and Faraday, who have coöperated to that end. At present Prof. Tyndall is held in peculiarly high esteem, both in England and in the United States, on account of his talent for popular expositions of scientific subjects. Any one who is conscious within himself of the gift and the power of working in a particular direction for the mental development of humanity, has usually a pleasure in such activity, and is ready to devote to it a good share of his time and his energies. This is especially the case with Prof. Tyndall. He has, therefore, remained true to his post at the Royal Institution, though other honorable posts have been offered him. But it would be quite an erroneous conception to think of him merely as the able, popular lecturer; for the greater part of his activity has always been given to scientific investigation, and we owe to him a series of (in part) highly-original and remarkable researches and discoveries in physics and physical chemistry.

In his discourse "On the Scientific Use of the Imagination," delivered before the British Association at Liverpool, Prof. Tyndall has given a peculiarly characteristic description of his manner of intellectual working. There are two ways of searching out the system of laws in Nature—that of abstract ideas, and that of thorough experimental research. The former way leads ultimately, through mathematical analysis, to an accurate quantitative knowledge of the phe-

nomena. But it can only advance where the other has already, in some measure, opened up the region, i. e., given an inductive knowledge of the laws, at least, for some groups of the phenomena belonging to it, and the point is merely the testing and clearing up of the already-found laws, the passage from them to the last and most general laws of the region in question, and the complete unfolding of their consequences. This other way leads to a rich knowledge of the behavior of natural substances and forces, in which at first the law-element is recognized only in the form in which artists perceive it, through vivid sensuous contemplation of the type of its action, in order to a later working out of it in the pure form of an idea. These two sides of the physicist's work are never quite separate from each other, though sometimes the diversity of individual gifts will adapt one man for mathematical deduction, another for the inductive activity of experimentation. Should the first method, however, become wholly divorced from actual observations, it falls into the danger of laboriously building castles in the air, on unstable foundations, and of not finding the points at which it may verify the agreement of its deductions with fact. The second, on the other hand, would lose sight of the proper aim of science, if it did not work toward ultimately bringing its observations into the precise form of the idea.

The first discovery of laws of Nature previously unknown, that is, of new forms of likeness in the course of apparently unconnected phenomena, is a matter of sense (taking the word in its widest meaning), and must nearly always be accomplished only by comparison of numerous sensuous perceptions. The perfection and purification of that which has been found fall afterward under the working of the deductive method of thinking, and preferentially of mathematical analysis, as the final question is ever about equality of quantities.

Now, Mr. Tyndall is *par excellence* an experimenter; he forms his generalizations from extensive observations of the play of natural forces, and carries over what he has seen, in some cases to the greatest, in others to the smallest relations of space (as appeared in the lecture referred to). It is quite a mistake to consider what he calls imagination as mere fancy (*Phantasterei*). It is exactly the opposite that is meant—full sensuous contemplation. To this mode of working is evidently to be attributed the clearness of his lectures on physical phenomena, as also his success as a popular lecturer.

EDITOR'S TABLE.

THE AMERICAN SCIENTIFIC ASSOCIATION.

THE American Association for the Advancement of Science held its twenty-third meeting at Hartford, in August, under the presidency of Dr. Le Conte, with a very good attendance. The address of the retiring president, Prof. Lovering, was an elaborate and able document, devoted to the discussion of prominent questions in modern physics; and a large number of miscellaneous papers, of the usual interest, were contributed to the proceedings. But while the Hartford meeting was one of average interest, in respect of the amount and quality of its scientific work, it was especially important in relation to the history of the domestic management of the Association. The constitution was revised, and the revision had reference to old and radical difficulties in the organization. As the American Association is the leading representative of the interests of American science, and as there is not a little misapprehension on the part of the public regarding its aims and policy, it will be desirable to give a brief account of its origin and character, that the import of the recent changes may be made intelligible.

The usefulness of organizations for the promotion of scientific objects is nowhere questioned. It is indispensable that scientific men should associate in order to carry on their work, and societies devoted to scientific objects, general and special, have accordingly sprung up within the last two centuries in all the leading civilized nations. The astronomers, the botanists, the geologists, the zoologists, the chemists, have all had their societies for the promotion of research and the extension of knowledge in their respective departments, while other institutions have aimed at the same ends by more comprehensive plans of organization. These associations naturally confined their membership to the cultivators of special original research in their several departments. But, with the rapid growth of science in later years, with the multiplication of its interests and the recognition of their powerful bearing upon public welfare, it began to be seen that the old organizations were inadequate to the general wants, and that new associations must be called into existence better adapted to meet them. One of the earliest expressions of this tendency was seen in the formation of the "British Association for the Advancement of Science," which was established in 1831, and held its first meeting at York, under the presidency of Earl Fitzwilliam, F. R. S. It was to be of a migratory character, holding its annual sessions in different towns; and it admitted to membership all who attended the first meeting, and in general all members of scientific societies, scientific professors, and those devoting themselves in any way to the promotion of scientific objects. There was obviously no intention that membership of the British Association was to be used or construed in the way of valuable indorsement of scientific position. The objects to be attained were general, and by no means the least of them was to act upon the public mind in such a way as to awaken a taste for scientific pursuits, to diffuse information, and incite an increasing interest in scientific matters. The aim of the organization was thus stated in the constitution: "The Association contemplates no interference with the ground occupied by other institutions. Its objects are—to give a stronger impulse and a more systematic direction to scientific inquiry; to promote the intercourse of those who cultivate science in different parts of the British Empire,

with one another, and with foreign philosophers; to obtain a more general attention to the objects of science, and the removal of any disadvantages of a public kind which impede its progress."

Two classes of institutions for the promotion of science, having the same general object, but working by different methods, were thus in operation in Europe when the question arose of forming a scientific association in this country. But the circumstances were so different here as to occasion perplexity at the outset in regard to its plan. In England, France, and Germany, there are old institutions of high character, like the Royal Society, the French Academy, and the leading universities, which carry out a stringent system of discriminations in regard to the claims and position of scientific men, and whose honors are so difficult of attainment that they become passports of character throughout the world. There were no such venerated and authoritative establishments in this country; and, when it was contemplated to enter upon the organization of a prominent and permanent society for the promotion of science, there were grave apprehensions that, in the absence of established tests, such a body would be inundated with inferior and incompetent men who would degrade its standards, impede its true work, and, perhaps, pervert it to unworthy objects.

The Association of American Geologists and Naturalists was established about 1840, ten years after the British Association. The geological surveys undertaken by the different States rendered meetings of those engaged in them very necessary, for comparisons, discussions, systematic effort, and the attempt at some common basis of geological classification. Very naturally it was a society of working men—of actual investigators—and aimed at objects which belonged to the province of original inquiry. In 1848 this society was reconstructed, and merged in a new organization called the American Association for the Advancement of Science, its first meeting being held in Philadelphia, under the presidency of William C. Redfield, Esq. In this change the original society was widened in its scope, and conformed to the general plan of the British Association. Its objects are thus stated in the constitution: "The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of the United States; to give a stronger and more general impulse and a more systematic direction to scientific research in our country; and to procure for the labors of scientific men increased facilities and a wider usefulness."

In comparing the statements of the objects of the two Associations, it will be seen that they are in certain respects identical, the English phraseology being adopted by the founders of the American Association to indicate its purposes. But the American organization, in the presentation of its objects, omitted an essential feature of the English, confining itself quite strictly to the promotion of the interests of scientific men as investigators, and omitting the English phrase, "to obtain a more general attention to the objects of science, and a removal of any disadvantages of a public kind which impede its progress." In a land preëminently of popular institutions, the new organization was less popular, in aim and spirit, than its foreign prototype—an anomaly which finds its explanation, as we have seen, in the circumstances under which American scientific men were laboring.

How early this feeling was entertained, and how serious were the apprehensions to which it gave rise, are well attested by the following passage from the address of Prof. Bache before the Association at Albany in 1851. No man could speak with more authority, as he was among its

founders, and presided over its third, fourth, and fifth meetings. He said: "When the effort was first made to establish a general American Association for the Promotion of Science, it is certain that it met with considerable opposition. There were various reasons for this. From close communication with many who are now active members of the Association, I know why this fear prevailed over their hopes of the usefulness of such an institution. The opposition came not more from those who were habitually conservative, than from those who, being earnest in regard to the progress of science, are usually in favor of all progressive measures. It proceeded from no under-estimate of the strength which there was among the cultivators of science. Some of us had studied the workings of the British Association, and had been convinced of the absolute necessity for the attendance there from year to year of the men of the universities, to give tone to the proceedings, and were alarmed, perhaps, at the forays into the domains of science, which had there been witnessed in some of the less powerful sections, and even into the park of Section A itself. So far from having been trained in the same schools, we scarcely knew each other personally. How could we irregulars venture into conflict, when the files to our right and to our left were strangers to us, and when the cause might thus have suffered from the want of discipline of its volunteer support?"

The difficulties thus anticipated made their appearance. It may be not quite just to say that they were provided for, but a course was pursued which could hardly fail to bring them on. The American Association for the Advancement of Science was organized on the general plan of the British Association; its meetings were to be held in different places, as if to create a public interest in science; the membership was made easily accessible, and the form of proceedings was the same. But while the British Association has had in it a strong popular element, which has been regarded as perfectly legitimate, while it has aimed to awaken sympathy for science, and arouse an interest in it on the part of the people, by providing addresses to be delivered during its meetings to popular audiences, by including a wide range of subjects of public moment in its sectional discussions, and by giving earnest attention to the general subject of scientific education, all these things have been studiously avoided by the American Association, which has constantly maintained that its function is the *creation* of science and not its *diffusion* or popularization. Its title has misled the public from the beginning. It is not an Association for the Advancement of Science, in the full or comprehensive sense of the expression, or as interpreted by the institution which first adopted it. Had it chosen a title which accurately described its character, such as "An Association for the Promotion of Science by Original Research," misunderstandings would have been avoided, and the difficulties feared at the outset might have been escaped. There would then have been a distinctive basis of membership; nobody would have been admitted that had not done something in the way of actual research, and the work of these would not have been embarrassed and impeded by the interference of outsiders. But in the actual working of the institution these difficulties have arisen. A portion of the membership, who claim to be the investigators for which the Association was established, complained that their proceedings have been hampered and overborne by the influx of scientific nobodies; and the said nobodies have complained that the concern was managed by a self-constituted and exclusive ring, who have spent as much time in admiring each other as in their proper

work, and have used the Association for the advancement of their personal objects and interests.

Dissatisfied with the results of this organization, several of its founders and most prominent members drew off in 1863 and organized the National Academy of Sciences. Its plan was an imitation of the French Academy; it allied itself to the General Government by which it was incorporated, and was limited to fifty members, with whom was the power of filling any vacancies that might arise. Here at last was an American institution sufficiently exclusive for the most exacting, and which could not be meddled with by the crowd of charlatans and incompetents without. It would seem that this arrangement, by giving original investigators a field of their own, ought to have met the difficulty and opened the way to the management of the original Association in a more liberal spirit. It is hardly too much to have expected that, when the National Academy had been organized on a basis which gave the most perfect protection to original investigators, and thus removed a serious American difficulty, the American Association might have widened its scope and placed itself upon the broad ground occupied by the British Association. But such has not been the effect. Instead of extending its scope and laboring to increase its general influence, the new constitution just adopted holds to the original aim of the Association, and concedes nothing to the growing popular demand for scientific guidance and enlightenment. Its main concernment seems to be still about scientific dignity, and it has actually entered upon the funny experiment of creating distinctions and distributing honors among its members. The old and troublesome question, "Who shall be greatest?" still vexes the souls of the managing magnates, who have solved it by the ingenious procedure of creating an order of "fellows." We have characterized this proceeding as funny, but if the bare fact be held as insufficient to justify such a characterization, then we have the further circumstance that the whole rabble of the membership are allowed to become "fellows" by the extra payment of two dollars apiece, which we think is certainly a very puerile piece of business.

We have very great respect for this Association, and believe that, notwithstanding its limitations, it has been productive of much good in this country. We have attended many of its meetings for the past twenty years, and found them instructive and profitable, while the past history of the organization affords ground of hope that it will be productive of still greater good in the future. But we believe that it would have been still more useful if it had been dominated by a broader spirit, and that as the interests of science are widening and deepening, and coming to be more generally recognized, it will be still more necessary in the future that the American Association for the Advancement of Science shall take them into earnest and systematic account.

NEW EXPERIMENTS IN EDUCATION.

It was an important step in the progress of knowledge when the bodily constitution of man began to be studied in the light of its relations to the inferior orders of life, and it promises to be a no less important step when the human mind is also so regarded. The study of mental manifestations in inferior creatures is becoming a systematic branch of inquiry, and the observers in this field are beginning to apply their method in the human sphere. We do not say that they have a new psychology, or claim to have arrived at any remarkable results; it is only noteworthy that those who have been engaged in discriminating among the mental likenesses and differences of horses, dogs,

pigs, and parrots, are attracted to similar observations upon the young of the different races of men.

Dr. W. Lauder Lindsay, a physician in charge of a Scotch lunatic asylum, but who has long been a special student of the subject of mind in animals, has sent a brief communication to *Nature*, giving the results of some experiments upon the mental capacities of children of different racial descent. The observations were made by Monsieur J. C. Houzeau, also a comparative psychologist, and author of "Studies on the Mental Faculties of Animals compared with those of Man." The observations were made in Jamaica, upon children inhabiting that island, and M. Houzeau states his experiments and conclusions as follows, in a letter to Dr. Lindsay:

"I have been busy, meanwhile, on a curious study about the comparative development of intelligence of children belonging to different races. I had an opportunity here to submit to the test black, brown, and white children. Fifteen of them were sent to me every day for two hours by their parents, my country neighbors: three of them white, seven colored of various shades, and five black. For a whole year I gave them myself common instruction, and carefully watched their proceedings and their rate of improvement. I do not expect to publish any thing about that experiment, at least at this time. But I will state here the conclusions to which it has led me:

"1. There is in each child a different degree of intellectual proficiency, which could be called, in mathematical language, his or her 'personal coefficient.' However, these individual differences are much less than I had anticipated, and are not the striking feature in the unequal rate or speed of improvement.

"In this unequal speed, I see nothing—at least nothing clearly and unmistakably discernible—that can be referred to the differences of race. This will probably appear strange after all that has been said of 'inferior races.' Should other facts show that my experiment was not properly conducted, and that the trial was not conclusive, I am ready to give up. Still, it is at least my 'provisional conclusion.'

"The rate of improvement is due almost entirely to the relative elevation of the parental circle in which children live—the home influence. Those whose parents are restricted to the narrowest gauge of intellectual exercise, live in such a material and coarse *milieu* (medium), that their mental faculties remain slumbering and gradually become atrophied; while those who hear at home of many things, and are brought up to intellectual life, show a corresponding proficiency in their learning."

Experiments upon so small a scale, and continuing for so short a time, must, of course, be inconclusive, for, as Dr. Lindsay remarks, "at or up to a certain age, girls are as sharp as or sharper than boys at lesson learning and repeating. Cases are constantly being recorded—perhaps paraded—in the newspapers of girls or young women beating boys or young men of equal age in competitive examination, and yet it is not to be inferred that the female mind is either superior or equal to the male, that is, in a comparison of averages. For the fact is, that, throughout the animal series, including man, the female mind, is, in some respects, different from, and inferior to, that of the male. We know, moreover, that female superiority, when it exists, is usually at least confined to school-life. In subsequent intellectual development proper, man, as a rule, far surpasses woman."

But, while M. Houzeau's observations were quite too restricted to form a basis of useful conclusions respecting the educability and intellectual capacity of the children belonging to different races, there is great significance in his final conclusion regarding the potency of home influences. This is no new truth, but it is a truth of transcendent importance, too much neglected, and its confirmation under such peculiar circumstances is noteworthy. That the medium in which the child is habitually immersed, and by which it is continually and unconsciously impressed, should have much greater value in the formation of mental character than the

mere lesson-learning experiences of the school, and should, in fact, determine the efficiency of the school-agencies themselves, is simply inevitable. Whether a child has the advantages of a quickening home, or is the victim of a stupefying home, is of far more moment than the quality of the school it attends. Home education is, after all, the great fact, whether it awakens or whether it quenches the young minds exposed to it, and it becomes a momentous question whether our exaggerated estimate and desperate cultivation of school-houses and public education are not at the expense of the far more important domestic influences by which the characters of children are formed. For we are learning every day that, as this world is constituted, one thing is at the expense of another. If parents believe that the school is all in all, and can do every thing for their children, such are the pressures and strains of social life that they will evade and neglect their own responsibilities. Their children will be committed to stupid and vicious servants, hustled out of the way, turned into the street, or left to themselves; and no pains will be taken to make the home medium one of elevation, stimulation, and improving to the mental characters of their offspring. Where men are exhausted in business, and women are exhausted by society, and there is blind faith in teachers and school-rooms, we may be pretty sure that but little will be done to shape and conduct the home with reference to the higher mental needs of the children who live in it. There are, no doubt, noble examples of parents who appreciate schools and strive to do their corresponding part of the work of exalting and enriching the intellectual life of those committed to their charge; but such cases are lamentably few, and there is reason to fear that, with the increasing faith in public appliances of culture, their proportion will not increase very rapidly.

PROFESSOR TYNDALL'S ADDRESS.

We publish in full the masterly inaugural address delivered August 19th, before the British Association at Belfast, by Prof. Tyndall, its President, for the present year. No scientific paper ever before published has produced so extensive and profound an impression as this. The eminent ability of the speaker, the dignity of the occasion, the confessed importance of the subject, and the eloquence and power of the statement, have all concurred to this result; but it has also been greatly due to that rapid diffusion of information upon the general question which has taken place within the last few years, and to the ripening of public judgment that has followed. In regard to this, Prof. Tyndall has calculated with great sagacity. Could the question have been submitted to the intelligent classes as to the propriety of such an experiment, probably nine out of ten would have condemned its folly and predicted its failure. Yet the address has actually been received with a unanimity of commendation that has fairly bewildered those who make it a business to study the drifts and currents of public sentiment. Some of the leading organs of public opinion, however, still affect to think that Prof. Tyndall has made a mistake, and that to spring upon the public mind this hitherto obnoxious discussion, under such peculiar circumstances, was in a high degree unwise, injudicious, and impolitic.

For example, the *Saturday Review*, while according to Prof. Tyndall's address much qualified praise, is still dissatisfied and captious, and objects to it as follows: "We confess that we were surprised that the President so wholly abandoned himself to elaborating one idea, and that one so distasteful to a large portion of those interested in science. . . . He has more than once, it is true, incurred great odium by the

outspoken way in which he has declared his opinions, and he has been pronounced rash for so doing; . . . we do not see why those who are not framed for special researches, but rather for being spokesmen of science, should bring odium upon it by trumpeting forth on occasions like these such of their beliefs as are most controverted even among themselves, and are most objected to by a large part of the outside world." And, speaking of his selection of a subject, the *Review* concludes that "while we fully appreciate the honesty of his motive which led to the choice, we much doubt its wisdom." The *New York Tribune* is even more decisively of the same opinion. It declared that "every sensible man will deeply regret that the address was ever delivered;" and, in a subsequent editorial, it reaffirms the judgment, "regarding Prof. Tyndall's demonstration as utterly unwise and unnecessary."

The question here raised is, by what kind of motives ought a man to be governed who has a great public duty to discharge as the representative of a body devoted to the advancement of scientific thought? Shall he meet his responsibilities like a man, or shrink from them like a coward? Shall he speak with honest fearlessness, or with a calculating caution? It is admitted on all hands that Prof. Tyndall chose the former alternative, and that his address was bold and courageous. This means, if it means any thing, that there was resistance to be overcome, and that it was so great as to call for the highest qualities of character to overcome it. There were ignorance, prejudice, narrowness, misunderstanding, and intolerance, in regard to a grave subject that had grown up in the world of science. A great opportunity came to him to treat this question as science treats all questions, to place it in a new light, and fix the world's attention more closely upon it. He might have taken counsel of prudence and timidity, and refrained from stirring up the disagreeable elements of hostility to an unpopular doctrine. But, pray, what are the circumstances in which the bold and courageous utterance of unacceptable opinions is to be ever justified? Can it be denied that the problems taken up by Prof. Tyndall are of transcendent importance, and are universally so regarded? And, if they were legitimate to discuss at all, what reason can be given for not treating them with the utmost thoroughness? Prof. Tyndall might, no doubt, have shirked the subject, to the comfort of many, and taken up some commonplace topic that would have disturbed the tranquillity of nobody. But there are plenty of men to rehearse the platitudes of science on occasions like this; and when one appears with the power of stirring the intellectual world to its depths, by the commanding treatment of a great theme, if he makes the utmost use of his opportunity, we see no reason for deploring it. More than this, he has no option in the matter; he is bound to be up to the utmost requirements of his duties and responsibilities. We offer no excuse for Prof. Tyndall, in taking the course he did—it would be an impertinence. He was forced by an obligation of honor to use his best powers for the advancement of the broad objects of the Association over which he presided; and his use of the occasion to vindicate the rights of scientific inquiry was the noblest service that he could perform. It has been said that his argument is superfluous, and that science has already the fullest liberty of investigation. It is true that the laboratories are not disturbed by the police; it is true that investigators are at liberty to publish their proceedings; but it is not true that the advance of science is without impediments and restrictions, nor is it true that men of science are left in perfect freedom to push their investigations undisturbed, to the utmost boundaries of knowledge. If they pass into cer-

tain departments of thought where there are facts and phenomena to be known, and knowledge is to be extended, they are denounced as impious intruders; and we can no more say that the mind is free in its action when loaded with execration for taking this or that course, than we can say that the body is free in its movements when loaded with chains. Prof. Tyndall came to this country to lecture upon physics. He stuck strictly to his text, and raised no questions in regard to the scope of scientific inquiries. But he was not let alone. At the banquet he received before leaving us, he was lectured upon the subject of the limits of science, and in the name of religion was bidden to keep in his place, and not attempt to solve the great questions of the origin and end of the world by running his head into the mud of mere physical speculation. Those things, he was told, are not for science, but belong to philosophy and revelation. The fundamental question of the Inaugural Address was thus here publicly thrust upon him from the religious side, and he was instructed what it was proper and what it was not proper for him to do as a scientific inquirer. Both the wisdom of the instructions and the propriety of giving them were extensively indorsed by the press of the country. Prof. Tyndall was, therefore, not let alone, and left free to pursue his course as a scientific man, but his course was dictated to him by the party that does not make science its business. His critics now have their reply, and we hope it is satisfactory. That he has not minced matters, but has met the issue manfully and squarely, we think is to the credit of the side he represents.

In wholesome contrast to the time-serving lamentations above quoted, we give some passages from an editorial in *Church and State*, a religious newspaper, which shows a heartier appreciation of Prof. Tyndall's work:

"It is one of the most conspicuous benefits of the study of physical science, that its most difficult and fundamental problems may be approached with absolute honesty. To find out the exact truth, whatever it may be, and to give it accurate expression, is the very business of science. The most skillful and successful investigators are always searching for new facts, by which their own provisional conclusions and working hypotheses may be either verified or corrected. They are so far from resenting new discoveries, that they themselves expose to view the weak places in their theories and generalizations, with the very object of calling universal attention to their *weakness*. They understand no triumph except the triumph of seeing for themselves, and helping other people to see, *that which is*.

"It is surely a gain to theology and religion that the most influential thinkers of our time—for it would be idle to deny that 'science' is the fashion—are pledged, not only by their own high character, but by the very nature of their pursuits, to absolute truthfulness, and to the most unflinching courage. Even Biblical interpretation would gain largely—and has, in fact, achieved all its modern triumphs by its adoption of an inductive method. Instead of setting out with certain authorized dogmas, and finding 'proofs' for them, somewhere or other, in the sacred Scriptures, our modern scholars set out with some book of Scripture, ascertain its authorship, its date, the readers for whom it was intended, the circumstances in which it appeared, and *its actual meaning*.

"And when we approach the ultimate problems, not only of religion, but even of life, it is well that we should be made to understand what the issues really are; and Prof. Tyndall has rendered us this service in his address to the British Association—an address so brilliant and noble that we have to lay it aside for a while, and come back to it, for sober criticism, in a calmer mood. No doubt, on both sides, it will be misrepresented, but there it is—stating questions that must be answered, facts that must be accepted and included in any theory either of mind or matter. We shall hope to give a fuller account of it before long; but its concluding words are worthy of the most solemn consideration of all of us who love the truth, however widely we may differ in our conclusions from Prof. Tyndall himself."

LITERARY NOTICES.

THE SCIENCE OF LAW. By SHELDON AMOS, M. A., Professor of Jurisprudence in University College, London. International Scientific Series, No. X. 417 pp. Price $1.50.

PROF. AMOS has written a book which will prove peculiarly acceptable at the present time; for, although discussions in respect to the application of the scientific method to social affairs are becoming commonplace, there is, nevertheless, a profound interest in the general question, and there is certainly a strong desire to know what can be done by that method in a field which is at once so practical and so unpromising as that of law. Whatever may be said about it, it is an undeniable fact that science has effected a foothold and begun to make itself at home in social inquiries, and it is certain not to go backward in the future. Moreover, in no region of thought have greater changes already occurred in the modes of inquiry than in the study of society. The old conceptions of history as the exponent of social life and progress are declining, and in their place we see steadily growing the conception of society as a sphere of phenomena in definite relations, to be analyzed, described, and classified, in the same way as any other department of Nature. Facts are to be observed and generalized, uniformities traced, and inductions established, not exact, of course, as in the exact sciences, but with the utmost degree of accuracy that the case admits, until our knowledge of the subject shall be reduced to scientific order. The group of social phenomena that are termed legal affords no exception to this tendency. Jurisprudence, indeed, has not formerly been wanting in its scientific form; in fact, it could not be systematically dealt with at all without involving the rudiments of a scientific method; but later investigations have tended increasingly to show how arbitrary and insufficient these methods were. The work of Prof. Amos is at the same time a landmark of progress and a reëxposition of legal facts and principles in the direction which is certain to be pursued in the future.

The two English writers, leaving out Bentham, whose labors have done most in developing the science of law, are Austin and Maine. Though both expositors of the same subject, they worked in entirely different ways. Austin, after describing the nature and province of law, examined and analyzed the fundamental conceptions which are common to all legal systems, and deduced from such analysis the principles of logical classification. In accepted language Austin occupied himself with the philosophy of law. On the other hand, Maine takes legal institutions as they are and have been, and traces them back to their earliest forms. He brings into full view the order of evolution and the influences which determined the course and progress of legal ideas. These two methods, the historical and analytical, are not opposed to each other as competitors, one of which must prevail. They really complement each other; the fruits of both are needed; they run into each other at every point. In our opinion, there is still another line of inquiry which must be taken up to complete the explanation of legal phenomena. Laws are made to effect definite purposes; they are the means by which certain actions and relations of mankind are regulated. Law-making is surrounded with the most difficult problems, and has for its only guide considerations educed from experience and the constitution of human nature and society. These purposes and, to a certain extent, these problems, the student of law must investigate; to stand outside, refusing to touch them, invites fatal criticism. We should say, then, that the scientific treatment of law includes the analysis and classification of legal conceptions; inquiry into the origin and evolution of legal institutions; and the theory of legislation. Prof. Amos adopts this view, and it colors every chapter of his work. He has dared to be comprehensive, and so has given us a treatise which will have a permanent value. Every department of law is explored in the directions indicated, and with all the fullness that can be expected in a popular book. The author travels over a wide field; and he is a guide that turns the attention of his readers to every part, pointing out the most important features with unusual skill and exactness.

Such being the general plan of the work,

the author commences the treatment of the subject by devoting the first three chapters to certain preliminary matters relating to the recent history and present condition of the subject, the province and limits of the science of law, and an analysis of the relations of law and morality. In the following chapters we have an account of the growth of law, and this statement is exceedingly interesting. The steps in the evolution are distinctly marked, the manner in which the changes were effected are clearly traced, and the sources whence materials were drawn for the constant process of improvement are pointed out. The latest and best-credited speculations on the origin of law, customs, equity, and methods of legislation, are also carefully presented. The sixth chapter is an analysis of primary legal terms, such as "person," "thing," "right," "duty," "act," "event," "intention," etc., all of which have complex meanings in jurisprudence. Separate chapters are given to such subjects as contracts, ownership, crimes, procedure, international law, and codification; and these are all treated with admirable clearness.

This little book deserves to be widely welcomed by the reading public. The names are few, in the list of great writers belonging either to this country or England, who have made contributions of any weight to legal science; Prof. Amos comes forward to do what he may toward supplying this deficiency, and he has proved himself equal to the task. He has produced a work on the science of law which will not only have its interest for the legal profession, but will have a greater interest beyond that profession. It has not been written for the specialist, but for general readers, and conveys in a popular form a kind of knowledge which has never before been reduced to convenient shape for general acquisition. And in this country especially, where everybody is or ought to be more or less concerned in the work of law-making, and where principles are required for guidance in the discharge of this duty, a work which strips the subject of its arbitrary and local features, and develops its universal and scientific aspect, should be widely welcomed and carefully studied.

It is proper to remark in this place that Prof. Amos has undertaken a formidable task in first attempting so great a novelty as to educe the general principles of the science of law, and then to present them in a compendious form adapted to all classes of intelligent readers. It was impossible that a pioneer work of this sort, dealing with subjects which have been habitually regarded from other points of view, should not be very tempting to critics who are ever on the lookout for something to slash; and we note that some of the English periodicals are very free in their strictures upon the professor's book. But, although finding fault with some of its minor points, its main characteristics have not been assailed, and the practical value of the treatise is conceded in all quarters. It supplies an urgent and an undoubted want, and will be a valuable addition to the "International Series" for which it was prepared. J. G. M.

THE RELATIONS OF CHRISTIAN EDUCATORS TO THE MODERN PHASES OF SCIENCE. By DANIEL S. MARTIN, A. M., Professor of Geology and Natural History in Rutgers Female College. From the Proceedings of the University Convocation, held at Albany, 1873.

WE have read this address with much interest, as it comes from a thinker who views the subject from both its sides—that of a thorough mastery of the modern problems of science, and that of the most stringent orthodoxy. He therefore not only recognizes "the fact of a long and lamentable controversy between Christian and scientific modes of thought," but he sees that both parties are at fault in provoking and maintaining it. On the scientific side, the causes of alienation are assumed to be—1. A "disposition to exclude the idea of God, which has appeared so strangely in the writings of scientific and philosophical students," and which he is unable to explain except on the hypothesis "that the whole race is in some way morally perverted and alienated from God and all true excellence;" 2. "Apart from an absolute and intentional advocacy of atheistical ideas, there is, on the part of many scientific men, a carelessness, or even a hostility of expression toward religious truth which awakens deep distrust;" 3. The perversions and misrepresentations of pretenders to science who assume its name to assail religion.

On the religious side, the causes of conflict pointed out are: "1. The absorbing claims and responsibilities of the ministerial calling, and the overshadowing weight of great moral themes; 2. A lingering half-doubt as to the legitimacy of the spirit of universal investigation; and, 3. A want of sympathy and intercourse with men of scientific pursuits." To these is added the want of a proper scientific education on the part of religious students, and to this the writer adds: "One of the last and most important points worthy of especial mention, as a cause of difficulty and alienation, is the harsh and captious mode of speech employed by many religious and other critics toward the views of men of science. How freely are such terms as 'infidel,' 'materialist,' 'unbeliever,' etc., applied to men who have really neither made nor intended any unkind allusion to religious men or religious truth, but whose discoveries have led them to the presentation of views which, marking an advance in scientific conceptions, involve, perhaps, some changes in the outward form of conceiving certain scriptural statements! Instead of calm and fearless inquiry, they are met with stern and positive denunciation. Instead of looking to see what new and valuable expansion of even our scriptural conceptions may be found, many religious men at once raise the cry of infidelity, and force the unhappy investigator of Nature into a position of hostility which he never designed to assume. I myself was never more surprised than on finding the magnificent generalization of the unity and convertibility of material forces assailed on charges of this kind."

THE PHILOSOPHY OF SPIRITUALISM, AND THE TREATMENT OF MEDIOMANIA. Two Lectures. By FREDERIC R. MARVIN, M. D. New York: Asa K. Butts & Co. 12mo, 63 pp. Price, $1.00.

THE well-known doctrine of the correlation and equivalence of forces is here called in to account for the phenomena of spiritualism. Assuming that thought is the utilization by the brain of a force correlative and interchangeable with the other forces of the universe, it follows that the force thus utilized may be converted into other forms of force, and thereby made to move a table, insensibly communicate the thoughts of one person to another, and do many other seemingly inexplicable things. In this light a table, dancing over the floor by itself, and spelling out marvelous communications, is a very natural performance. It is the result of a train of forces set in motion by the brain of the medium, consciously or unconsciously, usually the latter. Thoughts long forgotten by a spectator, but still unconsciously present in his mind, may be unconsciously communicated to the medium, and by him revealed.

Mediomania is regarded as a species of insanity allied to hysteria, chorea, etc. It is produced generally by derangement of the sexual organs. Like other disorders, it is susceptible of treatment and cure. The book is interesting, and its conclusions are in accordance with the existing tendencies of scientific thought.

MANUAL OF GEOLOGY: Treating of the Principles of the Science, with Special Reference to American Geological History. By JAMES D. DANA. Second edition, with over 1,100 Figures, and a Chart of the World. 828 pages. Price, $5.00. New York: Ivison, Blakeman, Taylor & Co. 1874.

THE first edition of this valuable work and standard text-book of American geology was published in 1862. It is now revised, much extended, and brought down to the present date, by incorporating the results arrived at by the most eminent investigators in various departments, among whom acknowledgments are made to Meek, Marsh, Worthen, Lesquereux, Hall, Newberry, Winchell, Gilbert, Wheeler, Collett, Knapp, Broadhead, Dawson, Billings, Johnson, Verrill, Hayden, Holmes, Gardner, Hawes, and Bradley. From such a wide range of contributions to so progressive a science as geology, the task of revision was most laborious, but it has been very thoroughly performed by the author, so that his work stands alone as an exposition of the present state, both of the general science of geology and its American applications. Nor is it merely a *résumé* of the latest facts; they have all been incorporated into the structure of the work, and, by contributing to the further advancement of the science, they give to the present volume greater unity and completeness than were

possible in the first edition; for with the increase of knowledge the science has been perfected. Professor Dana recognizes the advances that have been made in elucidating the progress of life upon the globe, and gives in his adherence to the great doctrine of evolution, although entertaining speculations of his own in regard to the mode of its working. He admits that "the evolution of the system of life went forward through the derivation of species from species according to natural methods not yet clearly understood, and with few occasions for supernatural intervention." The modifications in the new edition which have reference to the doctrine of evolution are very significant.

THE SHIP OF FOOLS. Translated by ALEXANDER BARCLAY. 2 vols. Edinburgh: William Patterson. New York: Appletons. 1874. Price, $25.00.

THIS curious old book was written by Sebastian Brandt, a German ecclesiastic, two years after the discovery of America. It is a popular poetical satire, directed against the vices and follies of the times just before the Protestant Reformation; but the sorts of people that provoked Brandt to ply his satirical lash are not without representatives in our own day; and hence, as a book of instruction, the "Ship of Fools" is by no means out of date. Soon after its publication it was translated into Latin, Dutch, Low German, and French; and in 1509 it was rendered into English by Alexander Barclay. The work now possesses mainly a philological and bibliographical interest, and has been expensively reproduced in exact fac-simile, in type, text, and illustrations, of the original edition. The English version is rather an adaptation of the original to English modes of life than a mere translation. It is well observed in the introduction: "Barclay's 'Ship of Fools' is not only important as a picture of the English life and popular feeling of his time; it is, both in style and vocabulary, a most valuable and remarkable monument of the English language. Written midway between Chaucer and Spenser, it is infinitely more easy to read than either." The language is strongly Saxon. Of the original work it is said that, "for upward of a century it was, in Germany, a *book of the people* in the noblest and widest sense of the word; and it was assumed to be so familiar to all classes that, even during Brandt's lifetime, the German preacher, Gailer von Kaiserberg, went so far as to deliver public lectures from the pulpit on his friend's poem, as if it had been a scriptural text."

THE PSYCHOLOGICAL AND MEDICO-LEGAL JOURNAL. New Series, No. 1. July, 1874. Conducted by WILLIAM A. HAMMOND, M. D., assisted by T. M. B. CROSS, M. D. $5.00 per annum. New York: F. W. Christern.

THIS is a continuation, in a new form, of Dr. Hammond's *Quarterly Journal of Psychological Medicine*, and it will probably take a more popular shape in its new phase of development. The leading article of this number is a complete report of the chief editor's address before the Neurological Society, on the "Effects of Alcohol on the Nervous System." It details the results of many experiments made by Dr. Hammond upon himself, to test the physiological influence of various forms of alcohol, and is an interesting and instructive contribution to the literature of the subject. The discussion which followed the address, by various physicians, is given; and there are several important notices and reviews of works upon psychological and medico-legal questions. The periodical is at present a monthly, but this is, perhaps, provisional. It is well printed, and has a neat and attractive aspect.

UNITED STATES COMMISSION OF FISH AND FISHERIES. Part I. Report on the Condition of the Sea-Fisheries of the South Coast of New England in 1871 and 1872. By SPENCER F. BAIRD, Commissioner. With Supplementary Papers. Washington: Government Printing-Office, 1873.

FOR many years, in this country and Great Britain, both popular and scientific opinions have been much vexed by the question whether the great harvest of the sea was not in danger of very serious diminution. It seemed to be generally thought, those only objecting who were engaged in such matters, that nets, wears, pounds, etc., were fast exterminating our food-fisheries. It was even argued by many fishermen that,

when the hook and line only were used, they fared much better, in the long-run, than they have done since the pursuit has enlisted capital, and brought into requisition, like other departments of industry, the most effective methods. It was certainly true that, of some species, the diminution had become so serious, that what was once a cheap food had become an expensive luxury; and, in respect to others, the supply was so precarious, that the prices were always good, and sometimes oppressively high. In this state of things the fishermen made their appeal to legislation, and the legislators in turn referred the whole matter to the men of science. We remember an old Professor of Hermeneutics, who said in his manual that Science had its apostles as well as the Gospel. The sentiment gave offense to many of his co-religionists, and his publishers asked to be allowed to take out the objectionable sentence. The professor firmly refused: "For," as he said to us afterward, "my regard for truth would not permit it." The United States ordered a commission to attend to this matter. No salary is provided, and no perquisites are possible. Can the men be found who will speak with the force of authority, and without the inducement of hire? With Spencer F. Baird to lead, a noble band of workers take up the cause—Baird and Gill, the ichthyologists; Dr. Farlow, the algologist; Profs. Verrill and Smith, of Yale College, the one so famous on the polyps, and the other on the crustacea; Mr. Emerton and Prof. Morse, noted specialists in the invertebrata—and there were chemists and meteorologists also. And all without fee or hope of reward, beyond the consciousness of the great good that must ensue from the accumulation and distribution of trustworthy knowledge on the great question of conserving the food-fishes. It became necessary to search old, musty records of the Puritan days, in order to know what its supply was in times gone—the migrations of fish, their food, the actual climate of the waters they frequent, and where they are scarce, and their food. Hence came deep-sea dredgings, and thermometric soundings, and explorations of sea-bottoms, and the chemical condition of the waters in different places and at different depths, etc., etc. The results appear in part in this thick volume. Besides a large amount of work in their best vein, Profs. Baird and Gill have given catalogues of the fishes, and Verrill and Smith of the invertebrates. The work of the former gentlemen is yet incomplete, and another year must continue the publication. That of Verrill and Smith has a sort of completeness, and it is well that this part is republished; and, as it is accompanied by many illustrations, it is to the student of these forms invaluable.

ESSAYS AND ADDRESSES, BY PROFESSORS AND LECTURERS OF OWENS COLLEGE, Manchester. London: Macmillan & Co. 560 pages. 8vo. Price, $5.00.

THIS volume is intended to commemorate the opening of the new buildings of the Owens College, which occurred on October 7, 1873. This college was founded in 1851, by a bequest of John Owens, a merchant of Manchester. In 1871 it was reconstituted and incorporated by act of Parliament. A sketch of its origin and progress is given in the "Opening Address" by the Duke of Devonshire, its president.

In the address "On Some Relations of Culture to Practical Life," Prof. J. G. Greenwood, the principal of the college, enters the controversy between the classical and scientific methods of education, and endeavors to stand upon middle ground. Instead of a principally classical curriculum, or the reverse, he would have one which embraces *letters* to cultivate the taste, *mathematics* to discipline the reason, "and some branch of *physical study*" to develop the powers of observation and inductive reasoning.

The lecture on "Solar Physics" is an interesting summary of our knowledge regarding the appearance of the sun, his atmospheric changes, his meteorological connection with the planets, and the connection between his magnetic changes and auroral displays.

"Primeval Vegetation in Relation to Natural Selection and Evolution" is a criticism, by Prof. W. C. Williamson, of those doctrines in the light of apparently contradictory facts furnished by the vegeta-

tion of the Cretaceous and Tertiary epochs. These facts are, that a great variety of forms appear to spring suddenly into existence, during those epochs, without the existence, in preceding epochs, of other forms from which they could have descended; and the presence of more highly-organized forms than we are led to look for on the grounds of either doctrine. The issue is made in a special, not a general sense. The general fact of evolution is taken for granted, while the special fact, that the implied variations of species are endless, is called in question. The position assumed is that such variations are limited.

In "Some Historical Results of the Science of Language," Prof. A. S. Wilkins draws a very entertaining picture of the condition, customs, and manners, of the prehistoric Aryan people, from glimpses afforded by the implications of the words they had in use; his object being to show what light has been thrown upon the distant past by the study of philology.

Among the remaining essays, "Original Research as a Means of Education," "The Distance of the Sun from the Earth," "The Limits of our Knowledge of the Earth," "The Use of Steam," "Science and Medicine," "Provençal Poetry in Ancient and Modern Times," "The Judicature Act of 1873, in its Relation to the History of the Judicial System of England," and "The Peace of Europe," will prove of interest to the general reader.

REPORT ON THE GEOLOGICAL SURVEY OF THE STATE OF IOWA TO THE THIRTEENTH GENERAL ASSEMBLY, January, 1870; containing Results of Examinations and Observations made within the Years 1866 to 1869. By CHARLES A. WHITE, M. D. 2 vols. imperial octavo, pages 391 and 435. Price $10.00. Des Moines, Iowa: Mills & Co.

THE first four chapters of this work are devoted to the physical geography of the State, which is admirably presented. In the first of these the author considers the surface features of Iowa, and gives in a chart five profiles across the State, showing elevations above low water in the Mississippi at Keokuk. From these it appears that the highest point in the State is but a little over 1,200 feet above the lowest, and that these two points are nearly 300 miles apart. The drainage of the State consists of two systems of rivers, an eastern and a western system, emptying, the former into the Mississippi, and the latter into the Missouri. As there are no mountains, the rivers constitute the most conspicuous feature in the physical geography of the State, and all its irregularities of surface are due almost solely to erosion by streams. The inconsiderable lakes of Iowa the author divides into two classes, viz., *Drift Lakes*, those whose beds consist of depressions in the drift, dating from the glacial epoch, and *Alluvial Lakes*, formed by the action of rivers. In the second chapter we have a discussion of the origin of the drift, in which the evidences of its glacial origin are set forth with a degree of clearness which is truly admirable. The two remaining chapters of this first part are devoted to the consideration of soils and climate. The author offers no opinion as to the *origin* of the prairies, but he holds "without the least hesitation that the real cause of their present existence in Iowa is the prevalence of the annual fires. If these had been prevented fifty years ago, Iowa would now be a timbered instead of a prairie State."

In Part II., General Geology, the author considers, among other points, the question of practical coal-deposits, and is confident that coal may be sought for over the whole of Southwestern Iowa, with reasonable hope of finding plentiful supplies at available depths. The present known coal-area of the State is about 7,000 square miles. The existence of large quantities of good peat has also been fully demonstrated. Explorations for mineral oil or the precious metals in any part of the State are almost certain to end in failure.

In Part III. of the first volume, and Part I. of the second, those portions of the State which have been examined in this survey are, as far as practicable, subdivided into regions that have common geographical characters, for the purpose of facilitating their description. A general account of each region is followed by separate and more detailed descriptions of every county within it, so far as they have been examined. Finally, Part II. has four chapters on mineralogy, lithology, and chemistry. But space

would fail us to signalize all the excellences of this work, which has the rare merit of being truly *readable* for the unprofessional and unscientific man. As regards the mechanical style of the work, it is in all respects admirable. The paper is of the best quality, the type large and clear, the proof-reader's duty faithfully done, and the woodcuts, charts, and plates, equal to the best. We would call special attention to the "Geological Map-Model" of the whole State. This consists of a map of Iowa in six sheets, whereof the lowest represents the Lower Silurian formation, underlying the entire State; over this the Upper Silurian, which covers all the foregoing except the extreme northeast corner; then the Devonian, which retires still farther back from the northeast corner; then in succession the sub-Carboniferous, the Lower and Middle Coal-Measures, the Upper Coal-Measures, and the Cretaceous.

A PLAIN EXPOSITION OF THE THEORY AND PRACTICE OF LIFE ASSURANCE, WITH A BRIEF SKETCH OF ITS HISTORY. By J. H. VAN AMRINGE, Professor of Mathematics, Columbia College, New York City. New York: Charles A. Kittle, 765 Sixth Avenue. 1874. 8vo, pp. 61.

LIFE insurance is "a subject of which, though some of the details may be complicated, the first principles are singularly plain." So wrote De Morgan, thirty-six years ago; a period within which there have been created in America seventy life-insurance companies now existing, the details of whose business are before us; of whose policies about 917,000 are now in force, insuring about $2,331,000,000, with a yearly income exceeding $125,000,000, and holding assets amounting to $375,000,000. These enormous sums are the insurances, and yearly and accumulated payments, in behalf of beneficiaries, who doubtless exceed 3,000,000 in number; and of fully nineteen-twentieths of these interested persons it is safe to say that they know nothing of the "first principles," so "singularly plain," of which De Morgan spoke, but of which he said, "nothing but indifference can prevent the public from becoming well acquainted with."

Of publications professing to popularize ideas about life insurance there are enough and a surfeit; but, the greater part of them being openly written in advocacy of some particular company, they are regarded by most people as advertisements, to be hastily read and carelessly cast aside. It seems, therefore, that, for an authoritative exposition of the principles and practices of the business, the public will regard the more such a presentation of the subject as has now been made of it by Prof. Van Amringe, who, from his position, will not be suspected of writing in the interest of any company or class of companies.

In his preface the author says: "The object of this pamphlet is to dispel the apparent mystery which envelops assurance—to give the general reader a clear and concise explanation of the principles on which it is founded, and their application in business. Purely technical discussion has been avoided, and the necessary calculations have been made in as plain English as possible. A simple explanation has been given of the several kinds of companies and their management; of the mode of obtaining a policy, and the conditions upon which it is issued; of the manner of securing the amount due under a policy when it shall become a claim; of the various kinds of policies issued; of the construction and use of mortality tables; of net premium, expenses, and loading; of reserve for reinsurance, lapse and surrender of policies; of surplus, its distribution and modes of application; of government protection of policy-holders and supervision of companies. An outline sketch of the history of life assurance, particularly in the United States, has been added."

In the accomplishment of his task, Prof. Van Amringe has been, in our judgment, very successful; a large amount of information has been condensed into moderate space, and at the same time clearly set forth, while there is no attempt at mere display of learning or of research; though the treatise is the result of a good deal of both. The work is, as a whole, so well done that we omit any mention of the two or three minor points we had marked for criticism; excepting this one which the professor can readily amend in his next edition. Life *assurance* is scarcely known in this country. Life *insurance* is well known, and is the subject which Prof. Van Amringe has

treated. The use of the word *insurance* is all but universal among American insurance men; and the distinction made in the use of the term, in the foot-note to page five of the pamphlet, is merely one of Babbage's crotchets.

We agree with President Barnard in saying that the general circulation of Prof. Van Amringe's pamphlet will "do much to inspire confidence among the people in the wisdom and safety of this mode" (life insurance) "of providing against the uncertainties of the future."

STATISTICAL ATLAS OF THE UNITED STATES. PART III. VITAL STATISTICS. By FRANCIS A. WALKER.

THIS is the first published installment of a series of maps and charts to comprise a "Statistical Atlas of the United States," designed to represent to the eye: 1. The physical features of the country; 2. The constituent elements and growth of population; 3. The vital statistics. The first and second parts will be published shortly. The third part, which is before us, comprises six maps and twelve charts. The maps, by variety of coloring, show the distribution of the statistical facts over the United States; while the charts, by a system of projected lines and shading, elaborate the details of the general idea, showing the facts as presented by States, sex, race, and age. For example: the first map shows the predomination of sex. Areas in which females predominate are left uncolored, while the remaining areas are colored deeply in proportion as the excess of males increases. The accompanying charts comprise a series of projections formed on the following principle: A vertical line, one inch long, is divided by horizontal lines into eight parts, representing as many decades. The angle to the left of the vertical line is supposed to represent males, and that to the right, females; and the shading of either angle indicates the predomination of the sex it stands for. Figures attached to the ends of the horizontal lines indicate by thousandths the number of individuals in each decade of life. The lowest horizontal line represents the first decade, and the length of each varies with the number of individuals in the decade it represents. In this way is shown the proportion between males and females in the aggregate population, the white, the colored, the foreign-born, etc., in the United States as a whole, and in severalty. The birth-rate, and the death-rate from consumption, malarial diseases, intestinal diseases, and fevers other than malarial, are represented in like manner. The statistics of blindness, deaf-mutism, insanity, and idiocy, are shown in charts only. An explanatory text, to accompany the maps, will soon be issued.

BUILDING, CONSTRUCTION TIMBER, AND BRICK. By R. SCOTT BURN. New York: G. P. Putnam's Sons. 2 vols. 16mo, 135 pp. each. Price 75 cents per vol.

THESE little volumes aim at explanation of the technical terms used in building, and description of the parts they designate, entirely avoiding the larger subject of the principles upon which the art of building rests; or, more definitely, they explain what any part of a building is without telling how the building, as a whole, is constructed. The first takes up timber construction "as exemplified in the framing of floors, partitions, and roofs, explains the terms and describes the parts, and proceeds in the same manner with the subject as exemplified in doors, windows and internal fittings of houses," and with the lead and iron work connected therewith. The second similarly deals with the employment of brick, stone, slates, tile, etc., in building.

Each volume is accompanied by another volume of corresponding size, containing plates illustrative of the text.

INORGANIC CHEMISTRY. By Dr. W. B. KEMSHEAD, F. R. A. S., F. G. S. New York: G. P. Putnam's Sons. 187 pp., 16mo. Price, 75 cents.

THE aim of this book is the expression of primary principles, so as to be intelligible to beginners, while also serving as a text-book for more advanced students; and it answers this purpose very well. It begins by defining inorganic chemistry, enumerating the elements, stating the laws of affinity and combination and the principles of chemical nomenclature, and concludes with a description of the most important elements, and the combinations into which they enter.

ALCOHOL; ITS COMBINATIONS, ADULTERATIONS, AND PHYSICAL EFFECTS. By Colonel J. G. DUDLEY. New York: G. P. Putnam's Sons. 68 pages. 25 cents.

THIS useful pamphlet is a popular restatement of the chief facts and arguments derived from science, upon which the opponents of alcoholic beverages rest their case. For his motto, Colonel Dudley quotes the pithy observation of Dr. Willard Parker that "the laws of health are the laws of God, and as binding on man as the Decalogue;" and he then proceeds to show how the laws of health are violated by the use of spirituous drinks. The author does not profess to have made any new contributions to the question, but only to present the opinions of eminent authorities, who have given great attention to the subject. His pages present many startling facts suited to awaken serious reflection on the part of those who are in danger from the use of alcoholic beverages, but the freshest portion of the statement is his *exposé* of the outrageous system of cheating practised by the dealers in spirits. Of all the frauds of commerce, according to this writer, none will for a moment bear comparison with the adulterations and sophistications of intoxicating liquors. He gives recipes enough for the manufacture of all kinds of choice liquors to start a manufacturer in business, and shows, by the cheapness of the material used, how immensely profitable such a business must be. To the rising generation, who cannot have the benefit of the teachings of the old temperance campaign, such works as this of Colonel Dudley will prove valuable, and its wide circulation among them is to be strongly commended.

EPIDEMIC DELUSIONS. By FREDERIC R. MARVIN, M. D. New York: Asa K. Butts & Co. 28 pp., 12mo.

IN a lecture before the Liberal Club of New York City, the author endeavored to point out the causes of popular delusion in general. The lecture is here produced in book-form. Inherited tendencies to passion and ignorance in the masses, automatic action, sympathy, and the desire to imitate, are assigned as the causes. The cultivation of a healthy public sentiment is regarded as the only cure.

A RECORD OF EXPERIMENTS SHOWING THE CHARACTER AND POSITION OF NEUTRAL AXES. A Paper read before the American Society of Civil Engineers, by LOUIS NICKERSON, C. E.

THIS paper records a series of experiments undertaken to ascertain the character and position of neutral axes (unstrained parts) in beams and columns under pressure, and attempts to establish, as the result of such experiments, "that the neutral axis is a flexible line truly parallel to the top and bottom sides of the rectangular beam, and passing through the centres of gravity of its sections only when the load is evenly distributed from end to end; . . . but that, when there is a local pressure, the neutral axis is more or less governed in its direction and form by the strain passing from the point of local pressure to the point of support."

PAPERS CHIEFLY ANATOMICAL. Read before the American Association for the Advancement of Science, August, 1873, by BURT G. WILDER, M. D.

THESE are: Discussions of the Outer Cerebral Fissures of Mammalia, especially the Carnivora; Cerebral Variation in Domestic Dogs; Lateral Asymmetry in the Brain of a Double Human Monster, and Papillary Representation of two Arms in the Same; Habits and Parasites of Epeira Riparia; Need of a Uniform Position for Anatomical Figures; Lateral Position of the Vent in Amphioxus and in Certain Batrachian Larvæ; Composition of the Carpus in Dogs; Present Aspect of the Question of Intermembral Homologies; Variation in the Condition of the Sense-Organs in Fœtal Pigs of the Same Litter; Pectoral Muscles of Mammalia, and Variation of the same in Domestic Dogs. The papers are illustrated by numerous plates.

THE MECHANICAL PROPERTIES OF MATERIALS OF CONSTRUCTION. Read before the American Society of Civil Engineers, by Prof. R. H. THURSTON.

THIS is an attempt to formulate methods for determining the homogeneousness, elasticity, and cohesive power, of metallic substances, as well as the effects produced in them by shocks or blows, strains, and variations of temperature.

BULLETIN OF THE CORNELL UNIVERSITY. Vol. i., Numbers 1 and 2.

NUMBER 1 gives some account of the Morgan Expeditions under Ch. Fred Hartt to the Amazonas country in 1870–'71, and describes the geographical, topographical, and geological features of the Lower Tapajos, while Number 2 describes the Carboniferous Brachiopoda of Itaituba, on the river Tapajos.

ASSAYING BY THE SPECTROSCOPE.—This is a paper detailing experiments made in the United States Mint at Philadelphia, by Alexander E. Outerbridge, Jr., with a view of ascertaining the possibility of determining the value of metals by the spectroscope. The conclusion arrived at is, that assaying by this means is impracticable.

TRANSMISSION OF CONSUMPTION. Read before the Maine Medical Association, June, 1874, by A. C. HAMLIN, M. D.

THE view taken is, that, by observance of natural law and judiçious selection in marriage, the ravages of this disease may be lessened; and the principal conclusions reached are, that persons of consumptive habits should not intermarry, and that consumptive mothers should not suckle their infants.

CONTRIBUTIONS TO THE GEOLOGY AND PHYSICAL GEOGRAPHY OF THE LOWER AMAZONAS, by CH. FRED HARTT; and THE DEVONIAN BRACHIOPODA OF ERERÉ, by RICHARD RATHBUN.

THESE two papers give some of the results of the Morgan Expeditions of 1870–'71 to the region named. The first is apparently a careful and elaborate description of the features of the Ereré-Monte-Alegre District and table-topped hills in Brazil, and of the formation of the strata composing the same. The second describes the fossil remains of molluscous animals discovered in the Devonian strata of that region.

NOTES ON THE MAMMALS OF PORTIONS OF KANSAS, COLORADO, WYOMING, AND UTAH. By J. A. ALLEN.

THIS is an enumeration of the families and species inhabiting those sections, and a description of their traits and habits.

THE RECEPTION OF DR. GOULD.—In the year 1870 Dr. Benjamin A. Gould went to Cordoba, in the Argentine Republic, at the request of its Government, for the purpose of establishing a national Astronomical Observatory, and of making observations on the constellations of the southern heavens. His recent return to the United States was celebrated in Boston by a reception given to him on the 22d of June last. On that occasion he delivered an address, narrating the nature of his labors, the difficulties overcome, and the results achieved. The principal results are, the successful establishment of the observatory, the establishment of a national meteorological office and system of observatories throughout the republic, and the compilation of an atlas of the heavens from 10° north of the equator to the south pole, showing every star to the seventh magnitude inclusive.

GEOGRAPHICAL VARIATION IN NORTH AMERICAN BIRDS. By J. A. ALLEN.

THIS is a paper describing the variation produced in birds by differences of longitude and latitude. In differences of latitude variations occur in color, size, and details of structural parts, while in differences of longitude the variation is principally in color. These variations are in some cases so marked, that similar forms have been classed as separate species.

TRANSFORMATIONS OF THE COMMON HOUSE-FLY. By A. S. PACKARD, JR., M. D.

AN interesting history of the changes incident to the life of this common insect. An individual lays about 120 eggs, usually in fresh horse-dung. The egg hatches in about twenty-four hours; the larva passes through three stages, occupying from five to seven days; the pupa state lasts about the same time; and, finally, the perfect fly appears at the end of ten to fourteen days from the time of hatching.

THE BENCH AND BAR REVIEW.—This is a new quarterly review, devoted to the interests of the legal profession, the publication of which was begun with the present year, in Baltimore. The leading articles in the first number are: "The Bar in England and France;" "The Civil Law: its Nature

and Genius;" and "The Responsibility of Life Insurance Companies." It is adorned with a portrait of Caleb Cushing, and also contains a biographical sketch of him.

PUBLICATIONS RECEIVED.

Archives of Electrology and Neurology. Edited by George M. Beard, M. D. May, 1874. 143 pages. Issued semi-annually. Price, $2.50 a year.

The Germ Theory of Disease. By E. P. Hurd, M. D. 1874. 14 pages.

The Pathology of Inebriety. By Joseph Parrish, M. D. Baltimore, 1874. 17 pages.

Agriculture as a Pursuit. Address delivered before the Agricultural Class of the State University of Georgia, by E. M. Pendleton, M. D. 10 pages. Atlanta, 1873.

General Meeting of the American Social Science Association for 1874. 32 pages.

On the Value of High Powers in the Diagnosis of Blood-stains. By Joseph G. Richardson, M. D. 9 pages.

Introduction to General Biology. By Thomas C. McGinley. 12mo, 200 pages. Price, 75 cents. New York: G. P. Putnam's Sons.

New Method of treating Malignant Tumors. By George M. Beard, M. D. New York, 1874. 16 pages.

Check-List of Publications of the Smithsonian Institution. July, 1874. 24 pages.

Little Stories for Little People. By James Barron Hope. Price, 10 cents. 1874. 26 pages.

On the Atmosphere as a Vehicle of Sound. By Prof. John Tyndall. 1874. 60 pages.

On the Dissociation of Certain Compounds at Very Low Temperatures. By A. R. Leeds. 3 pages.

Rules of Evidence as applicable to the Credibility of History. By William Forsyth. London, 1874. 22 pages. Price, threepence.

Bulletin of the Minnesota Academy of Natural Sciences. 1874. 150 pages. Price, 50 cents.

The Compound Steam-Engine. By John Turnbull, Jr. New York: D. Van Nostrand & Co. 1874. 44 pages. Price, 50 cents.

Intellectual Culture. By Edward R. Palmer, M. D. Louisville, 1874. 20 pages.

The Protoplasm Theory. By Edward Curtis, M. D. New York, 1873. 23 pages.

Community of Diseases in Horses and other Animals. By W. Lauder Lindsay, M. D. 37 pages.

Review of Darwin on Expression. By Alexander Bain. London, 1873. 16 pages.

The Vermiculites, their Crystallographic and Chemical Relations to the Micas, etc. By Josiah P. Cooke, Jr. 1873. 32 pages.

Resources of Tennessee. By J. B. Killebren. Nashville, 1874. 8vo, 1193 pages.

Evidences of the Antiquity of Man. By James H. Whitmore. Rochester, 1874. 26 pages.

MISCELLANY.

Fritz Müller on Bee-Habits.—A letter to Mr. Darwin from Fritz Müller, dated Itaguahi, Brazil, April 20th, confirms many of the observations of Mr. Belt's remarkable work, "The Naturalist in Nicaragua," on the habits of ants. Further, he gives the following account of a contest between the queen-bee of a hive and the workers: A set of forty-seven cells had been filled, eight on a nearly-completed comb, thirty-five on an adjoining one, and four around the first cell of a new comb. When the queen had laid eggs in all the cells of the two older combs, she went several times round this circumference (as she always does, in order to ascertain whether she has not forgotten any cell), and then prepared to retreat into the lower part of the breeding-room. But, as she had overlooked the four cells of the new comb, the workers ran impatiently from this part to the queen, pushing her, in an odd manner, with their heads, as they did also other workers they met with. In consequence, the queen began again to go around on the two older combs; but, as she did not find any cell wanting an egg, she tried to descend, but everywhere she was pushed back by the workers. This contest lasted for a rather long while, till

at last the queen escaped without having completed her work. Thus the workers knew how to advise the queen that something was as yet to be done, but they knew not how to show her where it had to be done. In the same hive there appeared to be two political parties among the workers, dissenting about the construction of the combs, one destroying what the other had begun to build.

The Western Grasshopper Plague.—A lady correspondent of a Western journal gives the most graphic description we have anywhere seen of the annoyance and discomfort caused by the grasshoppers during their recent invasion of some of the Western States and Territories. Writing from Northeastern Kansas, under date of August 5th, the correspondent states that then the grasshoppers were flying all around, and alighting on every thing, pelting against doors and windows as fast as hailstones ever came. It was scarcely possible to see through a screen door, on account of the insects swarming on the netting. Out-of-doors, the appearance was as though a severe snow-storm were raging, the wings of the flying grasshoppers looking white like flakes of snow. "They destroy every thing they alight on; every tree and shrub is covered with them. You know we read of Pharaoh's plague, where the insects got into the kneading-trough. I think this is one of them. I went out by the door to try and drive them off, and they flew all over me, and I had to change my dress to get rid of them. Instead of having rain, we are having showers of grasshoppers. Our six windows are completely covered with them, and as I write they are pouring down the chimney, and coming down the stove-pipe."

The Flora of the Black Hills.—General Custer, in a dispatch dated August 2d, graphically describes the botanical wonders of the Black Hills country, Dakota. Of "Floral Valley" he says that it surpasses in its display of flowers any public or private park he had ever seen. Every step of the march up that valley was amid flowers of the most exquisite colors and perfume. So luxuriant in growth were they that the troopers plucked them without dismounting. At one of the halting-places, General Forsyth plucked, choosing at random, seventeen beautiful flowers, of different species, and within a space of twenty feet square. The same evening, while seated at the mess-table, an officer called attention to the carpet of flowers under foot, and the question arose, how many different species could be plucked by the company without leaving their seats at table. Seven beautiful varieties were thus gathered. Prof. Donaldson, botanist of the expedition, estimated the number of flowers in bloom in Floral Valley at fifty, while an equal number of varieties had bloomed or were yet to bloom. The number of trees, shrubs, and grasses, was twenty-five, making the total flora of this valley embrace 125 species. Through this beautiful valley meanders a stream of crystal water, so cold as to render ice undesirable, even at noonday. The temperature of two of the many springs found flowing into it was ascertained to be 44° and 44½° respectively.

An International Pharmacopœia.—In the *American Journal of Pharmacy* for July 1st, Dr. Charles H. Thomas, of Philadelphia, calls attention to the serious disagreements existing between the British and United States Pharmacopœias; and strongly advocates the adoption of some measures by which the two books may be brought into greater accord, or, better still, fused into a single one. As they stand at present, the terms employed and the formulæ used are widely different, so that, while in the other departments of medicine what the student finds in the text-books and oral teaching of one country is common to both, in the department of materia medica, and in pharmacy, the variations and discrepancies could hardly be greater were it a case of two different languages. This condition of things operates as a great annoyance to the physician of one country wishing to practise in the other, and is still more aggravating to the teacher, who is unable to lay down any established rules of guidance beyond the limits of his own country, whereas these rules should be coextensive with the language.

Dr. Thomas thinks that the general adoption of the metrical, or some other

uniform system of weights and measures, must precede the introduction of an international or universal pharmacopœia, but that we are now on a footing for establishing "a unity of standard for the composition of the principal preparations of the pharmacopœias of the English-speaking people, and this notwithstanding the radical differences between the systems of weights and measures in Great Britain and in this country respectively—the expedient needed to be adopted being no other than for the United States and British Pharmacopœial authorities to unite in putting into force the rule established by the Scandinavian nations, at their international convention, held in 1865, when the pharmacopœias of Norway, Sweden, and Denmark, were unified, and which rule is, to express the relative quantities used in pharmacy in proportional parts by weight, as, e. g., two parts by any system of weight of the first ingredient, four of the second, and one of the third, etc., thus securing like relative proportions in all standard compounds."

The Colorado Potato-Beetle.—Some time since Prof. Charles V. Riley predicted that the dreaded *Doryphora decem-lineata*, or Colorado potato-beetle, would reach the Atlantic States in 1878, the prediction being based on the average progress eastward of fifty miles per year. But latterly the movements of this pest appear to have been accelerated, for our esteemed contributor, Dr. Samuel Lockwood, has, during the past summer, found potato-vines infested with the larvæ of the genuine Colorado beetle in West Freehold, N. J. From a communication by Dr. Lockwood to the *Monmouth Democrat*, a copy of which, with several additional notes inserted, has been kindly furnished us by the author, we take the following account of the researches which led to the identification of the New Jersey brood with the formidable Western insect-pest. Having secured some specimens of the larvæ from West Freehold, Prof. Lockwood placed them in a glass jar with a quantity of potato-leaves. They fed ravenously on these for some time; symptoms of the pupa change were then observed, and, some friable earth having been furnished, the larvæ burrowed into it, and soon assumed the pupa form. In due time the perfect beetle appeared. But, as there are two species of *Doryphora* (*D. decem-lineata* and *D. juncta*), one of which, the *D. juncta* or bogus Colorado beetle, is common in the Atlantic States, and, as both are very much alike in the beetle-form, Dr. Lockwood took every precaution to avoid error in his diagnosis.

In the larva stage the difference between the two species is decisive. Larvæ of the "bogus bug" have on each side the body a row of distinct, round, black spots, while larvæ of the true Colorado species have two rows of these spots on each side of the body. To make assurance doubly sure, Dr. Lockwood procured eggs from the beetles he had himself raised, and had larvæ hatched from them. There was now no room for doubt, for every one of them had the double row of spots. This conclusion is concurred in by Prof. C. V. Riley.

The capacity of the Colorado beetle for reproduction is amazing. They bear three broods in one season: one female has been known to lay 1,200 eggs. Says the Canadian *Entomologist:* "If the progeny of a single pair were allowed to increase without molestation for one season, the result would amount to over 60,000,000."

In anticipation of this insect reaching Europe from our Atlantic States, the German Government has made thorough preparation to meet it. Prussia has adopted a system of traveling lecturers on agriculture, *Wanderlehrer*. Each *Wanderlehrer* has a district of twenty or thirty miles, and his duties are to visit the farmers personally and instruct them. Specimens of the Colorado beetle have been supplied to these teachers, so that, through their instructions, the German farmers are already well informed as to this insect, in fact, know all about it, and can recognize it when it comes. If such a thing is possible, it will be destroyed on its first appearance.

The original home of this insect was Colorado. It is known that it lived upon the mountains there over fifty years ago, and that it fed upon the *Solanum rostratum*, a species of wild-potato. When the white man began planting potato-patches on the Rocky Mountains, better food, and in larger quantities, caused the great increase of the insect, which immediately began spreading

toward the East. In 1859 it had reached within a hundred miles of Omaha. In 1861 it had entered Iowa, and in 1865 had crossed the Mississippi into Illinois. Thus on it moved eastward, generally at about fifty miles a year, though latterly the movement must have been more rapid. The sad thing is, that every swarm that moves leaves a permanent colony behind.

Every device has been employed to destroy them. Paris-green has been dusted on the plants. This will kill all it touches. But its application is expensive, and not without danger. It was found necessary to use an ingenious machine drawn by two horses. This consisted of a large box supported by wheels. The box was open at the top, over which was a revolving flapper, or fan, that brushed the vines over the box, at the same time striking them, thus causing the beetles to fall to the bottom of the box, where was a pair of revolving rollers, between which they were crushed. There were other kinds of machines, but this was the most effective.

The Colorado beetle is about half an inch long, roundish, and in form much like a lady-bug. It has a series of ten stripes on each wing-cover, being alternately brown and yellow. It is a very beautiful insect; but, alas! it is among the most formidable of those diminutive enemies of the industry of man, whose depredations, even in the brief history of our nation, has cost us, in money loss of crops, more by many times than the sum-total of all our wars. Already, in Maryland, the ravages of the new-comer are filling the farmers with dismay.

Prof. Morse on the North American Unionidæ.—In his paper on this subject, at the recent meeting of the American Association, Prof. Morse explained, on the theory of natural selection, why the fresh-water mussels are so much more abundant in this country than in Europe, and why they are so much more numerous west of the Alleghanies than on their eastern slope. The families of fresh-water mollusks are few in number, and are intimately related with those families in the sea that have proved capable of surviving admixture with fresh water, and that commonly occur between high and low water mark. Many animals have adapted themselves to the changing influences which are liable to occur between high and low water mark, such as inundations, fresh water, and rain. Others have adapted themselves to brackish water, and, to those forms that have survived, the fresh-water mollusks are closely related. In this struggle for adaptation to new conditions, great modification of form takes place, a fact illustrated and confirmed by what has been observed in the case of the mya or common clam. This belongs between high and low water, and, although never yet so far changed as to live in fresh water, it has passed through almost innumerable modifications of form before giving up the struggle. Now, referring to the past geological history of this continent, we find, from the successive upheavals of the Laurentian hills to the North, the Alleghanies on the East, and the Sierras on the West, a gradual inclosing of wide inland seas, lagoons, whose drainage must have been toward the Mississippi Valley. These, in their gradual transition from briny to fresh water, would furnish all the conditions favorable to a transformation from marine to fresh water species; to be followed by an infinite number of fresh-water forms, according as the subsequent conditions varied.

Use of the Actual Cautery.—The "actual cautery" is commonly defined to be a *red-hot* iron used for burning or disorganizing the parts to which it is applied. The application of a red-hot iron directly to the living tissues is justly regarded as an extremely painful operation; but, if the iron be heated to a *white heat*, it is absolutely painless. The difference between the two is analogous to the difference between a bullet speeding at its maximum velocity, which may produce mortal injury without pain, and a nearly-spent bullet, which slowly lacerates the tissues and causes agony. Dr. J. S. Camden, writing in the *Medical Times and Gazette*, recites as follows his own experience with cauteries at different degrees of heat: "When actual cautery," says he, "is to be used, the iron must be heated till it is really of a white heat, and looks almost as white as white paper. If then applied it destroys the part instantaneously, giving no pain; but it must be removed quickly on the heat

decreasing, and then another iron employed. If a red-hot iron only is used, the agony is intense. The first time I saw the cautery used, on a girl of fourteen years, no pain was given; the second time, on an elderly person (both for fungus in the upper maxillary bone) her screeching was fearful, till I told the operator his irons were not half hot enough. He requested me to heat them properly, which being done, not a murmur was heard. The last time was opening four or five sinuses in a horse's shoulder. He never flinched and scarcely seemed aware of what was being done. I would suggest using—to obtain the white heat for actual cautery—a large spirit blow-pipe."

An Edible Lizard.—Dr. Burt G. Wilder communicates to the *American Naturalist* a brief note on the *Menobranchus maculatus* as an article of food. This animal he regards as probably a variety of the banded Proteus, or big water-lizard, but it is never striped, and always spotted. So abundant are they in Cayuga Lake that a single fisherman brought him a hundred of them during the month of March. The animal is held to be poisonous, and the fishermen dislike even to touch them. So far, however, is this from being the case, that they are absolutely harmless in every way. Dr. Wilder and his associate, Dr. Barnard, have eaten one which was cooked, and found it excellent. It is their intention to recommend the *Menobranchus* for food, but not until all their investigations into the anatomy and embryology of the animal are concluded.

Conversion of Wood into Lignite.—In one of the old mines of the Upper Hartz, in Hanover, some of the wood originally employed in timbering has become so far altered as to assume most of the characters of a new lignite, or brown coal. Many of the levels in the ancient workings of this mine are filled with refuse matter, consisting chiefly of fragments of clay-slate, more or less saturated with mine-water, and containing here and there fragments of the old timbering. When wet, this wood is of a leathery consistence, but in the air it soon hardens, having most if not all the characters of lignite. It breaks with a conchoidal fracture, and the parts that are most altered have the black, lustrous appearance of the German "pitch coals." Chemical examination shows that this altered wood is nearer to true coal than some of the younger tertiary lignites. From all this it would appear that the transformation of vegetable matter into coal requires less time than is usually estimated by geologists; in the present instance it cannot have been over four centuries.

Indictment of the English Sparrows.—In his "Key to North-American Birds," Mr. Coues expressed his apprehensions that the English sparrow would molest and drive away our native species. He now writes to the *American Naturalist* that these apprehensions have already been verified. From a letter written by Mr. Thomas G. Gentry, it appears that, in the neighborhood of Germantown, Pa., the English sparrows are driving away the robins, blue-birds, and native sparrows. "They increase so rapidly, and are so pugnacious, that our smaller native birds are compelled to seek quarters elsewhere." It is chiefly on this account that Mr. Coues has always been opposed to the introduction of the English sparrow, but also for other reasons. He holds that there is no occasion for them in this country, and that the good they do in destroying certain insects has been overrated. The time will come, he says, when it will be deemed advisable to take measures to get rid of these birds, or at least to check their increase.

Anatomy of the Porpoise.—Mr. Frank Buckland, having dissected a porpoise, gives some interesting information on the structure of that animal. In the matter of bowels it is well provided for, the specimen examined having 62 feet 2 inches of intestine. The stomach was so complicated that it could not be made out by ordinary dissection. To get round the difficulty, Mr. Buckland hung it up by the œsophagus, and filled it with plaster of Paris, of which nearly a pailful was required before the organ was fully distended. It was then found that the porpoise has two stomachs—one in which the prey is kept, and the other in which it is digested. A careful section of the head showed the blow-hole to be a most compli-

cated mechanism. The porpoise, being a pure mammal, has a four-cavitied heart, and a pair of lungs. Now, Nature has ordained that he shall live in the sea; the problem is, how to keep water out of the lungs. In the first place, his nose is guarded by a valve placed on top of his head, and when the porpoise breathes he comes to the surface, and takes a deep inspiration. Not a drop of water ever gets in. But how does he work his valve, and keep the water out of his lungs, when he is asleep? The answer to this question cannot be given yet. Mr. Buckland intends to study the subject when next he has a live porpoise at the Brighton Aquarium.

Reproduction of Ancient Colors.—A remarkable and very beautiful shade of blue is noticeable upon many of the ornaments found in the tombs of Egypt. Analysis, some time since, proved the color to be formed by a combination of soda, sand, and lime, with certain proportions of copper. From these substances the ancient Egyptians obtained three different products: first, a peculiar kind of red, green, and blue glass; second, a brilliant enamel; and lastly, this blue color, which was used for painting. By synthetic experiments, Peligot has succeeded in reproducing this peculiar shade of blue, by heating together seventy-three parts of silica, with sixteen of oxide of copper, eight of lime, and three of soda. The temperature should not exceed 800° Fahr., as, in such case, a valueless black product is the result.

Prof. Huxley on Female Education.—A lady, Miss Sophia Jex-Blake, having failed to pass successfully an examination at the Edinburgh University, brought the charge of unfairness against the examining board. One of the lady's papers, that on natural history, having been submitted to Prof. Huxley for his opinion, he expressed his full concurrence in the decision of the board, so far as this paper was concerned. In a letter to the *Times*, giving a history of the affair, Prof. Huxley remarks as follows on the question of woman's education: "Without seeing any reason to believe that women are, on the average, so strong physically, intellectually, or morally, as men, I cannot shut my eyes to the obvious fact that many women are much better endowed in all these respects than many men, and I am at a loss to understand on what grounds of justice or public policy a career which is open to the weakest and most foolish of the male sex should be forcibly closed to women of vigor and capacity. We have heard a great deal lately about the physical disabilities of women. Some of these alleged impediments, no doubt, are really inherent in their organization, but nine-tenths of them are artificial—the product of their mode of life. I believe that nothing would tend so effectually to get rid of these creations of idleness, weariness, and that 'over-stimulation of the emotions,' which, in plainer-spoken days, used to be called wantonness, than a fair share of healthy work, directed toward a definite object, combined with an equally fair share of healthy play, during the years of adolescence; and those who are best acquainted with the acquirements of an average medical practitioner, will find it hardest to believe that the attempt to reach that standard is likely to prove exhausting to an ordinarily intelligent and well-educated young woman."

Do Dogs perspire?—It is frequently urged, as an argument against the ordinary method of muzzling dogs, that it closes the mouth, and thereby prevents perspiration, which, in the dog, is said to take place only through the mouth. This, according to *Land and Water*, is an error; perspiration going on through the skin, as in other animals. The idea of perspiratory glands in the tongue is characterized as absurd, these organs being only found in the dog's skin, which is abundantly supplied with them. The real cruelty of the close or strap muzzle is, that it hinders free *respiration*, rather than free perspiration.

New Species by Sudden Variations.—A paper was read by Mr. Meehan, at the American Association, entitled "Change by Gradual Modification not the Universal Law," in which, after recounting a large number of facts in botany which go to show that varieties and new species are not always the result of imperceptible gradations,

but, on the contrary, may be produced at a single leap, the author draws the following conclusions:

1. Morphological changes in individual plants are not always by gradual modifications. 2. Variations from specific forms follow the same law. 3. Variations are often sudden, and also of such decided character as to seem generic. 4. These sudden formations perpetuate themselves similarly in all respects to forms springing from gradual modifications. 5. Variations of similar character occur in widely-separated localities. 6. Variations occur in communities of plants simultaneously by conditions affecting nutrition, and perhaps by other causes. From these premises Mr. Meehan argues that new and widely-distinct species may be suddenly evolved from preëxisting forms without the intervention of natural selection, and, of course, without the existence of connecting links.

Many who heard this paper were at first disposed to consider it an attack on Darwinism, its tendency being to lessen the importance of the principle of natural selection. But its discussion showed that such was not the view of those best able to judge; Profs. Morse, Riley, Gill, Gray, and even Mr. Meehan himself, regarded the argument as a contribution to the theory of evolution, while all but the author were of the opinion that it was quite consistent with the principle of natural selection, and, indeed, had already been taken into the account by Mr. Darwin.

Nitrogen of the Soil. — Prof. H. B. Armsby read at the American Association meeting a paper on the "Nitrogen of the Soil," in which, after stating that no plant has the power, so far as we know, of taking its nitrogenous materials directly from the atmosphere, he investigates the sources from which the nitrogen of plants is derived. Nitrogenous organic substances, such as exist in freshly-manured soils, may yield free nitrogen by decomposition, though the particulars of the process are as yet not fully ascertained. Under some circumstances these organic substances are capable of causing free nitrogen so to enter into combination with them as to increase their nitrogenous contents. This increase has generally been attributed to the formation of nitric acid from free nitrogen by oxidation. The author made a series of experiments on the loss and gain of nitrogen, his method being to allow organic matter containing a known amount of nitrogen to decay, under circumstances allowing measurement of the nitrogen given off or accumulated. The organic matter consisted of dried and sifted barn-yard manure, mixed with one-quarter its weight of dried and pulverized flesh. There were eight experiments in all, four of which were conducted in purified air, and four in purified nitrogen. The quantities and materials used for the two series of experiments were as follows:

I.

No. of Experiments.	Organic Matter.	Gypsum.	Potash.	Water.	Total Nitrogen.
	Grammes.	Grammes.	Grammes.	Cubic centimetres.	Grammes.
1	15	..	....	6	0.486
2	15	..	0.798	6	0.486
3	15	15	....	6	0.486
4	15	15	0.798	6	0.486

II.

1	15	..	....	6	0.453
2	15	..	0.798	6	0.453
3	15	15	....	6	0.453
4	15	15	0.798	6	0.453

The result of the experiments shows a loss of nitrogen in Nos. 1, 3, and 4 of Series I., amounting to 11.11, 6.21, and 13.09 per cent. respectively; and in Nos. 3 and 4, of Series II., of 1.14 and 1.94 per cent. No. 2, of Series I., shows a gain of 15.22 per cent.; and Nos. 1 and 2, of Series II., a gain of 1.48 and 19.34 per cent. respectively. The author's conclusions are: 1. The loss of free nitrogen during the decomposition of nitrogenous organic matter is generally due to oxidizing action. 2. An increase of combined nitrogen in soil may take place by oxidation of free nitrogen to nitric acid. 3. Some organic substances in the presence of a caustic alkali are able to fix free nitrogen without the agency of oxygen, or the formation of nitric acid.

Tea-Production in Bengal, British India.—In the entire presidency about 800,000 acres are "held for purposes connected with the tea-industry." Of this only about 70,000 acres are occupied with tea-plants in bearing. This portion is subdivided

into "mature-plant land" and "immature-plant land." The average yield of the mature-plant land is about 237 pounds per acre; that of the immature, about 80 pounds; of the whole, 208 pounds per acre. The total production is about 15,000,000 pounds.

NOTES.

PROF. CH. FRED HARTT, of Cornell University, sailed on the 5th inst. on his fifth expedition to Brazil, accompanied by one of his students, W. J. C. Brauner. He proposes to make a reconnoissance of the gold and diamond region north of Rio de Janeiro, and explore carefully several rich paleontological and archæological localities discovered on previous expeditions. It is his intention at the same time to review his studies on the Southern Glacial Drift.

THE entomologists of the American Association for the Advancement of Science have formed a special organization, to be known as the "Entomological Club of the American Association for the Advancement of Science," with Dr. John L. Le Conte as President, and C. F. Riley as Secretary. The Club will annually assemble one day in advance of the Association meeting, and hold other meetings during the session of that body. The objects, as stated by the *Tribune*, are the exchange and exhibition of specimens, and especially of types of such species as may have been described during the preceding year.

THE largest tree in Ohio stands in the Methodist parsonage-lot, Chillicothe. It is an elm, nearly eight feet in diameter, and 110 feet across the branches. Its height is not above 50 feet. The trunk is hollow, and has been so for many years. It is supposed to be four or five hundred years old.

BORELLY, of Marseilles, on the 26th of July, discovered a new comet. Prof. Swift, of Rochester, who was the first in this country to observe this comet, describes it (July 30th) as being quite large and bright for a telescopic comet. It has a strong central condensation, but no apparent nucleus or tail. It is in the fourth coil of Draco, and moves at the rate of about a degree per day.

GOLD and platinum have been drawn to a "spider-line" for the field of a telescope, by coating the metal with silver, drawing it down to the finest number, and then removing the coating by acid, leaving the almost imperceptible interior wire, which, in an experiment made in London, was so attenuated that a mile's length weighed only a grain.

A CORRESPONDENT of *Land and Water* gives the following instance of canine sagacity: A canary-bird having escaped from its cage, a cat in the room was seen gazing intently at some object under a chair. There lay a favorite terrier, with the canary firmly yet tenderly grasped in its mouth, all the while watching the cat, evidently with the object of keeping the latter at a safe distance from the bird. On being asked for the bird, the terrier instantly gave it up. It had received no injury whatever. How long the dog may have protected the poor little bird is not known, but the circumstance is at all events a notable instance of what is usually described as sagacity, but which may be more justly termed reason in the dog.

THE extraordinary drought of the past summer in Europe had a disastrous effect on the fishes. Near Asnières on the Seine, shoals of fish of all sizes lay on the surface of the water as if half dead or stupefied. A somewhat similar state of things appeared in the vicinity of Oxford, where fish of all sorts and sizes were picked up dead in the shallows. In many parts of Ireland the trout in the smaller streams have been nearly destroyed. The trouble at Asnières and at Oxford was no doubt the result of the poisoning of the Seine and the Isis by sewage.

A PIPE is now being laid for the conveyance of petroleum from the oil-wells of Millerstown, Pa., to the Baltimore & Ohio Railroad, a distance of 40 miles. The pipe is three inches in diameter, and its capacity 4,000 barrels per day.

THE Railroad Commissioners of Massachusetts have held a hearing on the subject of steam-whistles on railroads, and have recommended that they should be restricted in use to "cases of danger and the necessary management of freight-trains."

AT the end of July the amount of money contributed so far to the Agassiz Memorial Fund was $7,800.

THE sum of $1,000 has been deposited with the Franklin Institute by Uriah A. Boyden, of Boston, to be awarded as a premium to "any resident of North America who shall determine by experiment whether all rays of light, and other physical rays, are or are not transmitted with the same velocity." The memoirs, which are to describe in detail the apparatus, mode of experimenting, and results, are to be sent in to the secretary of the Institute by January 1, 1875.

AT the Priestley Centennial Meeting, Prof. Fraser urged the formation of a Chemical Society, to be independent of the American Association for the Advancement of Science, but the project was rejected. Dr.

H. C. Bolton's amendment was approved, appointing a committee of five to coöperate with the American Association at the August meeting, to establish the chemical section of that body on a firmer basis.

MONUMENTS to Liebig are to be erected both at Munich and at Giessen. At the Chemical Centennial, Prof. J. Lawrence Smith urged the raising of a subscription for these memorials among the chemists of the United States. The following subscriptions were announced, it being understood that they are to be devoted to the monument at Giessen: Prof. J. L. Smith and Prof. Silliman, $200 each; Prof. Horsford, $100; Prof. Chandler and Dr. Amend, $50 each.

THE Signal-Office at Washington has perfected arrangements with the various meteorological bureaus of European states, for an international exchange of weather reports. This coöperation cannot fail to be productive of highly-important results both for commerce and for science.

A COMMISSION of Icelanders is about to visit Alaska, to inquire into the prospects for the settlement of a colony of their countrymen in that Territory.

IN a letter dated Tokei, Japan, May 18th, and addressed to Prof. Joseph Henry, Prof. Henry S. Monroe says that carboniferous coal of the best quality has been discovered on the island of Yesso, in the tertiary formation; it is true bituminous coal. "So far as I know," says Prof. Monroe, "this is the first time that such perfect fuels have been found having so recent an origin as the Tertiary age."

THE cities of Lyons and Versailles on the one hand, and Paris on the other, have always differed very widely in the extent to which they have been ravaged by cholera. Paris falls an easy prey to the epidemic, while it has never gained a firm foothold in either Lyons or Versailles. M. Decaisne finds an explanation of this in the different characters of the soil underlying the three towns. Versailles is built on a bed of clay, impervious to water; Lyons stands upon granite; while Paris rests upon a porous foundation. M. Decaisne does not attribute the presence and absence of cholera to these facts alone, but his arguments are directed to show that they may exert a powerful influence.

A NOTE in the *American Chemist* by Mr. J. M. Merrick shows how some wines may easily be freed of their excess of acid, without in the least impairing their flavor. In the autumn of 1871, Mr. Merrick made from Concord grapes 120 gallons of wine, adding 1¼ lb. of sugar to each gallon of juice. By analysis made June, 1873, this wine contained 17.5 per cent. alcohol, but it was undrinkably sour. Analysis showed it to contain a little more than *one per cent.* of free acid, mainly tartaric. In September about seven pounds of neutral tartrate of potassa was added, with gratifying results: the color of the wine was lightened, and its hardness and sourness diminished. Into a gallon of another harsh, crude, and unpalatable wine, the author introduced a trifling amount of neutral tartrate of potassa, and by heating the wine to about 50° C. it became mild, and high flavored, without unpleasant acidity.

M. DUMAS has communicated to the French Academy of Sciences some experiments by Messrs. Troost and Hautefeuille on the hydrates of mercury or combinations of hydrogen with that metal. These combinations, it is said, so strongly resemble those which constitute the amalgams of mercury with silver and other white metals, that it is hardly possible to doubt that they are themselves amalgams, and hence that hydrogen is a metal, a fact apparently indicated in many other analogies.

MR. A. ENGELMANN, in the *Engineering and Mining Journal*, shows that rope tramways are no recent inventions, citing a figure of such a tramway, in a work dating from 1766. It is there stated that many years before, the Bishop's Mound at Dantzic was leveled by means of this machine, and carried across river, fields, gardens, and pastures. The drawing shows an endless rope passed over a roller attached to the side of upright posts, and at the extremities of the line over horse-whims; buckets are attached to it by thin ropes, spliced to the main rope. At each roller a rod is attached to a piece of the post, which, bending upward and outward round the roller, pushes the bucket-rope aside, and enables the bucket to pass by the rollers.

A PROFESSORSHIP of Textile Industries has been founded in connection with the Yorkshire College of Science, by the "Worshipful Company of Clothworkers." The incumbent of the new chair willl be required to have a practical knowledge of all materials used in the woollen and worsted manufactures; to be able to give practical instruction in every branch of weaving; to apply the laws of color to the production of colored designs; to explain and illustrate the processes of carding, combing, and spinning—in short, to be perfectly familiar with every aspect of textile industry.

THE *Lancet* "entirely and heartily" adheres to the principles and practice of cremation as set forth by Sir Henry Thompson. "Custom and sentiment," says the *Lancet*, "will prove formidable opponents to this reform; but all reforms meet with keen opposition, notably those connected in any

way with the public health. If this question, however, be viewed in a purely sanitary aspect, the arguments in favor of cremation are almost irresistible, and those who work at preventive medicine should add it to their code of subjects, and urge it continuously on the attention of the public."

THE most unhealthy city in Europe is Berlin. According to the *Lancet*, its death-rate amounts to 5.5 per cent. Munich comes next after Berlin. These figures speak ill for sanitary science in the German Empire.

A DISPATCH from the Washington Naval Observatory, dated August 10th, states that Prof. Newcomb has completed the approximate elements of Borelly's comet. It would pass its perihelion about August 25th, and would be visible with a telescope in the evening till about the end of the month, and in the morning during the whole of September, but would never be visible to the naked eye. The orbit, as determined by Newcomb, indicates that it is a new comet.

THE practice of dyeing Easter eggs first led to the discovery of the value of albumen as a mordant.

TWO expeditions are projected to set out from Archangel: the one to explore the traces of ancient glaciers in Russian Lapland; the other is to make zoological explorations of the littoral of the White Sea. Dr. Yarjinsky, who lately explored this region, found in the White Sea and the Arctic Ocean species of fishes and crustaceans entirely unknown hitherto.

TO determine the action of coal-gas on plants, J. Boehm placed the ends of willow cuttings in flasks containing a little water and filled with coal-gas: the cuttings developed only short roots, and the buds on the upper parts died soon after unfolding. Again, of ten plants in pots, with access of gas to the roots, seven died in four months. In all these cases the gas acts indirectly, poisoning the soil, and through the soil the plant.

A WRITER in the *Chemical News* calls attention to a source of error in mercurial thermometers, which does not appear to be generally known. His thermometer having been placed in a Wurtz tube, so that the column of mercury was entirely surrounded by the vapor of a distilling liquid, was, after some days, noticed to indicate three degrees too little. The discrepancy was found to have been caused by volatilization of the upper surface of the mercury and condensation on the upper part of the tube. By causing the mercury to flow to the end of the tube and back, the condensed portion was gathered up, and the correct temperature indicated.

A LUNAR rainbow of unusual brilliancy was recently seen by Mr. Charles W. Cottel, of Wilmington, Ill. It appeared about eleven o'clock on the evening of July 26th. The moon was nearly full, and almost due south; a light rain-cloud passed in a northwesterly direction: soon the moon was unobscured, and the conditions were the best for the observation of the phenomenon. A perfect bow was seen in the passing cloud, its apex having an elevation of about 40°. The bow continued visible for some twenty minutes. Much to his regret, Mr. Cottel was riding alone, and was unable to have his impressions of color verified by better eyes (his own in that respect being unreliable from disease); but to his vision the bands of orange and indigo were plainly distinguishable.

ONE of the precepts of the Law of the Twelve Tables, the most ancient code of the Romans, forbids the burying or burning of dead bodies within the limits of the city. It was but the other day, as it were, that this simple dictate of sanitary prudence came to be recognized among the moderns.

ENGLISH physicians are not allowed to practise their profession in the republic of Chili, without undergoing an examination in medical science, conducted in the Spanish language. The Chilians pretend to an excellent and wide-spread knowledge in medicine not attained by other nations, and they deny that English doctors are equal to their standard.

FROM Joubert's researches on phosphorescence, it appears that this property is possessed by arsenic and sulphur under certain conditions, viz., when subjected to a temperature of 200° C. and high pressure.

A CURIOUS phenomenon was observed by M. Tresca, on hammering the bar of platinized iridium recently prepared for the International Metric Commission. At each stroke there were produced rectilinear luminous flashes, which crossed each other in the form of an X, extending from one side of the bar to the other, and always in the same manner. No explanation is offered of the phenomenon.

A SORT of flute, dating from the age of polished stone, has been found by E. Piette in a layer of charcoal and cinders, in the cavern of Gourdan, Haute-Garonne, associated with flint implements of neolithic types. The instrument is of bone, and pierced with two well-made holes. This is the first discovery on record of a musical instrument belonging to prehistoric man.

THE Forty-seventh Congress of German Physicians and Naturalists will assemble at Breslau on September 18th, the sittings to continue till the 24th.

INDEX.

PAGE

About Crabs. (Illustrated) 191
Acoustic Properties of the Atmosphere 252
Action of Mucilage on Glass 624
Action of Sunlight on Glass 67
Actual Cautery, Use of the 762
Address, Tyndall's, before the British Association 652
Alligators swallowing their Young 506
American Scientific Association 741
Anderson School at Penikese 253
Animals, Are they Automatons? 724
" and Fire-Arms 507
" Extinct in the Historic Period 331
Antagonism between Growth and Reproduction 606
Aquarium, The. (Illustrated) 687
Architects, Microscopic. (Illustrated) 646
Atmosphere, The, as an Anvil 220
Australian Compliment to American Microscopes 382
Axial Buds in Juglans Nigra 124

Baby-Fox, A. (Illustrated) 443
Bees, Habits of 759
Birds-of-Paradise. (Illustrated) 557
" Soaring and Sailing of 253
Black Hills, Flora of 760
Books noticed:
"Principles of Mental Physiology" (Carpenter) 115
"The Principles of Science" (Jevons) 116
"Politics and Mysteries of Life-Insurance" (Wright) 118
"Contributions to Solar Physics" (Lockyer) 120
"The Martyrdom of Man" (Reade) 121
"The Structure of Animal Life" (Agassiz) 122
"Present Status of Social Science" (Hamilton) 122
"A Treatise on the Method of Government Surveying" (Clevenger) 123
"The Borderland of Science" (Proctor) 123
"The Galvanometer and its Uses" (Haskins) 123
"The Land of the White Elephant" (Vincent) 244
"What is Darwinism?" (Hodge) 246
"The Expanse of Heaven" (Proctor) 248
"The Philosophy of Herbert Spencer" (Bowne) 248
"Annual Record of Science and Industry" (Baird) 249
"The Kindergarten Messenger" (Peabody) 249
"Fuel" (Siemens and Wormald) 250
"Popular Key to the Birds, Reptiles, etc.," (Jordan and Van Vleck). 251
"First Lessons in the Principles of Cooking" (Barker) 250

Books noticed: PAGE
"Tabular Statements of the Agriculture of the United States" (Ruggles) 371
"Higher Schools and Universities in Germany" (Arnold) 373
"Krūsi's Drawing" 374
"The Doctrine of Evolution" (Winchell) 375
"Field Ornithology" (Coues) 376
"Proceedings of the Georgia Teachers' Association" 376
"The Great Ice Age" (Geikie) 377
"My Visit to the Sun" (Benson) 378
"The Principles of Science" (Jevons) 378
"Smithsonian Miscellaneous Collections; the Constants of Nature" (Clarke) 499
"Physiology for Practical Use" (Hinton) 499
"The American Annual Cyclopædia" 500
"Smithsonian Report for 1872" 501
"The Construction of Mill-Dams" 502
"Theory of the Glaciers of Savoy" (Rendu) 502
"Bulletin of the Buffalo Society of Natural Sciences" 502
"Anatomy of the Invertebrata" (Siebold) 502
"Free-hand Drawing" 503
"Logic, Inductive and Deductive" (Bain) 631
"Ancient Faiths embodied in Ancient Names" (Inman) 632
"Health and Education" (Kingsley) 632
"Catalogue of South Missouri Normal School" 636
"Bulletin of the Cornell University" 758
"Assaying by the Spectroscope" 758
"Transmission of Consumption" (Hamlin) 758
"Contributions to the Geology, etc., of the Lower Amazonas" (Hartt) 758
"The Devonian Brachiopoda of Ereré" (Rathbun) 758
"Mammals of Kansas, Colorado," etc. (Allen) 758
"Reception of Dr. Gould" 758
"Geographical Variation in North American Birds" (Allen) 758
"Transformation of the House-Fly" (Packard) 758
"Bench and Bar Review" 758
"The Science of Law" (Amos) 749
"The Relations of Christian Educators to the Modern Phases of Science" (Martin) 750
"The Philosophy of Spiritualism" (Marvin) 751
"Manual of Geology" (Dana) 751
"The Ship of Fools" (Barclay) 752
"The Psychological and Medico-Legal Journal" 752
"United States Commission of Fish and Fisheries" (Baird) 752
"Essays and Addresses by Professors, etc., in Owens College" 753
"Report of the Geological Survey of Iowa" (White) 754
"Theory and Practice of Life Assurance" (Van Amringe) 755
"Statistical Atlas of the United States" (Walker) 756
"Building, Construction Timber, and Brick" (Burn) 756
"Inorganic Chemistry" (Kemshead) 756
"Alcohol" (Dudley) 757
"Epidemic Delusions" (Marvin) 757
"Character and Position of Neutral Axes" (Nickerson) 757
"Papers, chiefly Anatomical" (Wilder) 757
"Mechanical Properties of Construction Materials" (Thurston) 757
Brain Development in the Mammalia 638
Brain, Functions of 505

Cautery, Actual, Use of the 762
Centennial Celebration 237
" of Chemistry 240
" of Discovery of Oxygen 493

PAGE
Chain, The, of Species 460, 568
Chemistry, Synthetic 39
Chloroform and Ether 507
Climate and Social Development 322
Coggia's Comet 637
Color in Animals 471
Colorado Potato-Beetle 761
Conditions affecting the Sex of Offspring 124
Crabs. (Illustrated.) 191
Cremation and its Alternatives 225
Crooked Courses of Light. (Illustrated) 32
Cyclones, Belt's Theory of 504

Darwin, Estimate of 475
Death-Point, Thermal, of Living Matter 695
Deposits in Steam-Boilers 124
Design, Doctrine of, and Evolution 98
Determination of Oxygen in Water 126
Development of Psychology 288, 412
Dicotyledonous Plants, Species of 254
Distances of the Stars 423
Dogs, do they perspire? 764
Dust of the Universe 626

Education, New Experiments in 744
" of Women 764
" Scientific and Industrial, in the United States 170
" Sex in 198
" War and 370
Electric Light for Steamships 720
Eozoon Canadense 127
Estimate of Darwin 475
Evolution and the Doctrine of Design 98
" Mental, and Necessary Truths 357

Female Suffrage 427
Ferments, Fermentations, and Life 543
Field Telegraph. (Illustrated) 303
Fish, English, in Indian Waters 126
Food and the Development of Man 591
Foreign Lesson and Domestic Application 108
Fossil Edentates 384
Fossil Man of Mentone. (Illustrated) 641

Genesis, The, of Woman 269
Gigantic Relic 94
Glass, Action of Sunlight on 67
" Action of Mucilage on 624
Grape-Vine Pest. (Illustrated) 158
Grasshopper Plague in the West 760
Great Lava-Flood of the West 381
Growth and Reproduction 606

Habits of Bees 759
Hair-Snakes 509
Have Plants a Pedigree? (Illustrated) 129
Helmholtz, Prof., Sketch of. (Portrait) 231
Hints on the Stereoscope. (Illustrated) 311
Humming-Birds. (Illustrated) 277
Hydraulics, The, of Great Rivers 327

PAGE
Ice, The Physics of. (Illustrated) 399
Improvement of Human Life 383
Insanity, Law and 77
Insurance Value 235

Jasmine Flowering Early 127
Joule, Dr. J. P., Sketch of. (Portrait) 103

Lake Superior Gold-Mines 380
Lava-Flood, The Great, of the West 381
Law and Insanity 77
" Science of 596
Le Conte, Dr. J. L., Sketch of. (Portrait) 622
Life, Human, Improvement of 383
Life in an Attenuated Atmosphere 379
Light, The Crooked Courses of. (Illustrated) 32
Limits of our Knowledge of Nature 17
Lizard, an Edible 763

Malayan Civilization, an Ancient Relic of 123
Man, Natural History of. (Illustrated) 513
Materials of the Science of Law 596
Measures of Mental Capacity. (Illustrated) 72
Mental Disease, Responsibility in 240
Mental Evolution and Necessary Truths 357
" Physiology 705
Mentone, Fossil Man of. (Illustrated) 641
Microscopic Architects. (Illustrated) 646
Moquis Indians of Arizona. (Illustrated) 351
More about the Grape-Vine Pest. (Illustrated) 158
Mound Prairies 506
Movement of Storms 639

Natural History of Man. (Illustrated) 513
Nature, Limits of our Knowledge of 17
Nature's Distribution of Trees 126
Nebula of Orion, Telescopic Research on. (Illustrated) 257
Need of a New Chronology 379
Newcomb, Professor 125
New Process for the Preservation of Wood 228
Nicaragua, A Naturalist's Observations in 89
Nitrogen of the Soil 765
Nobility of Knowledge 610
Nostalgia 215
Notes 127, 255, 384, 511, 640, 766

Ocean, Temperature of the 507
Orion, Telescopic Research on Nebula of. (Illustrated) 257
Oxygen Centennial 628
" Discovery of, by Priestley 385
" in Water, Determination of 126

Pacific, Topography of the Bed of 508
Paints, Why they crack and peel 381
Peabody Museum of Natural History 638
Pelican, An Aged 254
Penikese, Anderson School at 253
Pharmacopœia, An International 760
Photography, Recent Researches in 717

PAGE

Photosphere, The, and Sun-Spots. (Illustrated) 532
Phylloxera. (Illustrated) 1
Physics of Ice. (Illustrated) 399
Physiology, Mental 705
Plants, have they a Pedigree? (Illustrated) 129
" how they imbibe Ammonia 511
Pneumatic Dispatch 255
Polaris Voyage, Results of the 382
Porpoise, Anatomy of the 763
Potato-Disease 125
Potato-Beetle, The Colorado 761
Priestley, Sketch of. (Portrait) 480
" his Character 497
" Celebration 504
" his Discovery of Oxygen Gas 385
Principles, The, of Sociology 369
Prof. Tyndall's Address 746
Psychology, The Development of 288, 412
Punishing a Senior Wrangler 144

Raft, A New 510
Recent Progress in the Higher Education 630
" Researches in Photography 717
Relic, A Gigantic 94
Relics of an Ancient Malayan Civilization 123
Religion and Science 313
Rendu and his Editors 447
Reproduction of Ancient Colors 764
" of Organs in Fish 511
Researches on the Zodiacal Light 380
Responsibility in Mental Disease 240
Results of the Polaris Voyage 382
Rivers, Great, Hydraulics of 327

Science Minister for England 251
Science, Religion and 313
Scientific Association, The American 741
" and Industrial Education in the United States 170
Sex in Mind and Education 198
" of Offspring, Conditions affecting the 124
Shepherd-Dog, A Clever 127
Shepherd-Dogs 510
Skunk-Madness 510
Soaring and Sailing of Birds 253
Social Development, Climate and 322
" Science Association 367
South-Sea Surgery 509
Sparrows, English 763
Species, The Chain of 460, 568
" New, by Sudden Variations 764
Sponge-Fisheries 505
Stars, Distances of the 423
Steam-Boilers, Deposits in 124
Stereoscope, Hints on the. (Illustrated) 311
Stoves of Cast and Wrought Iron 509
Sun-Spots, The Photosphere and. (Illustrated) 532
Synthetic Chemistry 39

Tea-Production in Bengal 765
Telescopic Research on the Nebula of Orion. (Illustrated) 257

PAGE
Temperature of the Ocean 507
Theology, The Progress of 114
Thermal Death-Point of Living Matter 695
Trees, Action of Frost on Position of 508
" Nature's Distribution of 126
Tyndall's Address at Belfast 652
" " (Editorial) 746
" Relation to Popular Science 734

Unionidæ of North America 762
Universities, Actual and Ideal 46

Volcanic Eruption in the Sandwich Islands 379

War and Education 370
Who are the Propagators of Atheism? 365
Woman, The Genesis of 269
Wood, A New Process for preserving 228
" Conversion of, into Lignite 763

Young, Dr. Thomas, Sketch of. (Portrait) 360

Zodiacal Light, Researches on the 380
Zuni Indians of New Mexico. (Illustrated) 580

END OF VOL. V.